Materials Engineering in Product Design & Manufacture

Materials & Methods

August 1955

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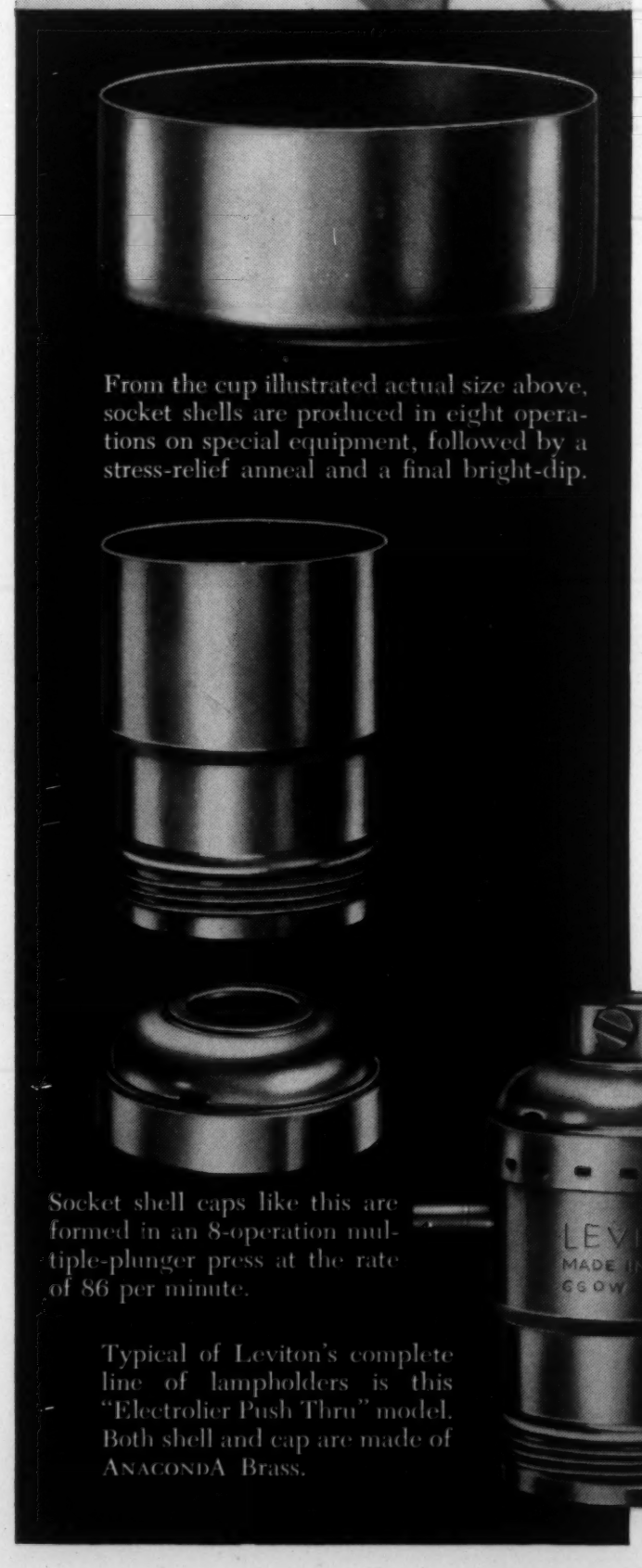
Joe Vuille says it's simple arithmetic:
"180 cups per min. x 60 min. x 40 hours per week x 5 weeks=

2,160,000 brass cups in one uninterrupted run"



From the cup illustrated actual size above, socket shells are produced in eight operations on special equipment, followed by a stress-relief anneal and a final bright-dip.

Socket shell caps like this are formed in an 8-operation multiple-plunger press at the rate of 86 per minute.

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With *Welding Grade*, their customers get all the benefits of standard cast Monel, plus the extra advantage of strong joining welds . . . an important point, when, as with Flowrator meters, equipment handles corrosive fluids at 6000 (or more) psig.

To learn more about both standard and *Welding Grade* Monel, write for Inco's new booklet, "Cast to Outlast."

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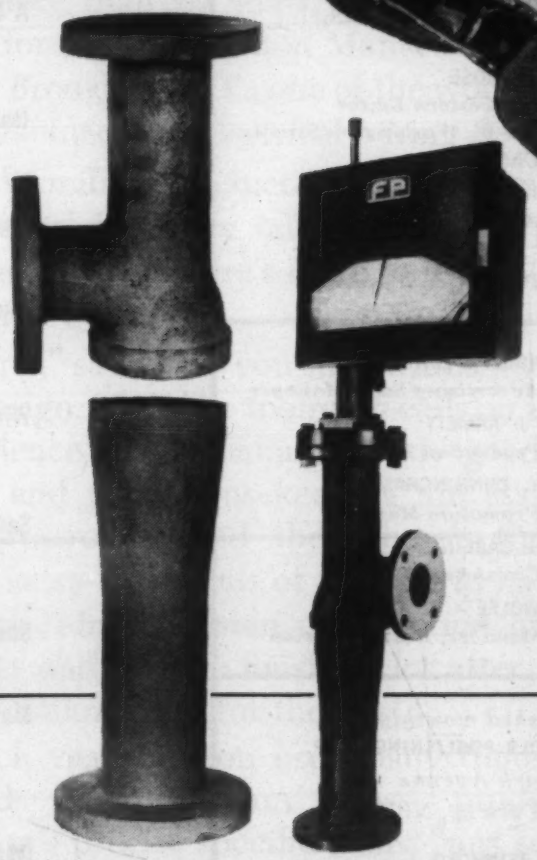

Production welded 600 psig Monel Flowrator meter and parts.

Armored Flowrator meters are made from these castings which have to be machined and welded together. They are used where high pressures or temperatures, liquid hammer or hazardous fluids make exposed glass metering tubes impractical. Fischer & Porter makes them of *Welding Grade* Monel Castings, in the type shown up to 600 psig (and in another design up to 6000 psig or higher) for handling fluorine, iodine, phosphoric and propionic acids, many of the chlorides and caustics, and certain other corrosives.

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Materials Outlook

PREMIX MOLDING, until recently a relatively minor process, is now being used to turn out thousands of reinforced plastic automobile parts each day. One application alone is reported to be consuming about 20% of the total production of polyester resin. An important factor in the growth of the process has been the development of a new engineering material - sisal-reinforced polyester, lower in strength but less expensive than glass-reinforced premix. (Full story in next month's issue.)

AN ELECTRICAL INSULATING MATERIAL that can withstand nuclear radiation and temperatures up to 1000 F has been developed. It consists of pulverized synthetic mica (only recently available) bonded with high-grade electrical glass, and is available in sheet and rod form. Previous formulations with natural mica were effective only up to 700 F.

NEW MATERIALS SPECIFICATIONS tentatively OK'd by the ASTM include copper-infiltrated iron powder parts; five grades of chromium-molybdenum steel plate for boilers and other pressure vessels; silver-coated soft copper wire; and six grades of titanium sponge.

ULTRASONIC INSPECTION OF SMALL TUBING is now feasible. New techniques with existing equipment make it possible to inspect tubing as small as 1 in., and one company has inspected tubing having 0.080 o.d. and 0.010 in. wall thickness. The new techniques are designed to eliminate or compensate for much of the surface reflection that previously obscured reflections from near-surface defects.

RUBBER-CLAD STEEL PLATE is now being marketed. Developed especially for chute linings, the new material consists of abrasion-resistant rubber sheet bonded to 1/16-in. hot-rolled steel plate. It can be formed, sawed, sheared, rolled, bent and punched like sheet steel.

A SERIES OF REFRACTORY COATINGS that can be applied to metals by flame spraying is now commercially available. Metals coated with the aluminum oxide, silicon carbide and zirconium oxide coatings are expected to be particularly useful for rocket, missile and ram jet parts exposed to temperatures in the 3000-3600 F range. (Full story in next month's issue.)

DATA ON THE EFFECT OF IMPACT on materials may become more common with the further development of an improved "impact tube" devised at New York University. The new instrument applies a sudden impact of controllable force to a specimen and measures the resulting stresses and strains by means of pressure gages and transducers attached to the specimen and connected to an oscilloscope. The oscilloscope signals are photographed to provide a record.

Materials Outlook

CREEP LIFE OF MOLYBDENUM at 1800-2000 F can be more than doubled by powder metallurgy additions of certain stable metal oxides, recent research shows. Most effective oxides are those of zirconium and titanium. . . . Nickel cladding, a possible answer to the high-temperature oxidation problem encountered with molybdenum, seems to have no effect on creep life but slightly lowers the elongation of molybdenum.

A SWITCH FROM NYLON to rigid, heat-resistant polyethylene in many industrial parts is privately predicted by developers of the most rigid of the forthcoming new polyethylenes. Not yet on the market, this new material is expected to cost only about one-fourth as much as nylon.

THE CHARPY IMPACT TEST, when properly conducted, is "truly an accurate and reproducible test" and hence a suitable acceptance test, says a spokesman for Watertown Arsenal. His statement came after a study of the causes of wide scatter in Charpy impact data reported in the literature.

A VACUUM BRAZING PROCESS FOR TITANIUM has been developed. Silver or silver-magnesium brazing alloy can be used to join titanium to itself or to stainless steel and other alloys. Complete brazing of ordinarily difficult joints is claimed. No distortion occurs, even in curved sandwich parts, because of the lower-than-normal brazing temperatures used. . . . Grinding is definitely detrimental to the fatigue life of titanium, a recent study shows.

TWO NEW REINFORCEMENTS FOR PLASTIC LAMINATES are being produced. One is a needled-batt structure of nylon, Orlon or Dacron fibers. Laminates based on these materials are expected to be especially suitable for critical electrical and high-frequency applications. The other reinforcement is knit elastic glass fabric in sleeve form. By conforming to complex mold contours, it eliminates many of the fitting problems ordinarily encountered by the molder.

FATIGUE STRENGTH OF MAGNESIUM alloy AZ31X is reduced by an HAE coating, according to an NBS scientist. Extent of the reduction, based on a life of 10^7 cycles, is about 1000 psi for each 0.001 in. of coating thickness.

MECHANICAL PROPERTIES OF IRRADIATED STEELS cannot be compared directly with the properties of the same materials before irradiation, a recent paper indicates. The authors point out that carbon steels have definite yield points before bombardment with high-energy neutrons, but none afterward. Conversely, austenitic stainless steels have no yield point before irradiation, but a definite yield point afterward.

Materials BRIEFS

Ultrasound and Wood

Ultrasonic techniques can be used to test for defects in wooden beams and standing timber. Vibrations of 440 kc and above improve the efficiency of dipping baths used to make wood water repellent.

Eyes Have It

The first successful shipping container for human eyes utilizes silicone gasketing, which will withstand both sterilization temperatures and ice-pack refrigeration without losing resiliency. Containers are used to ship eyes from hospitals to eye banks.

Shedding Light

Mildly radioactive porcelain enamel is now available for signs that glow in the dark. Trace amounts of radium oxide in the frit cause the material to luminesce continuously, even in areas of constant total darkness. Radioactivity is far below toxic levels.

Room for Expansion

Circular sheet metal parts for jet engines are deliberately fabricated undersize, then expanded to meet exact tolerances. Manufacturer finds the method eliminates oversized parts, which would have to be scrapped.

Cattle Carrier

An all-aluminum semi-trailer for cattle transport is now being manufactured which is 2800 lb lighter than steel and wood counterparts. The reflectivity of the aluminum sheet also keeps the cows cooler, gets them to market in better shape.

New Chemical Family

The development of esters based on boron that are resistant to water may lead to a host of new materials useful as plasticizers, brazing fluxes, paint adhesion promoters, and perhaps polymers.

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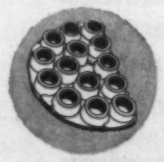
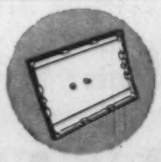
Ace-Hide acid pail



Molded top for golf bag



Large molding is lid for beverage cooler

Ace-Hide is a new rubber-plastic molding material designed to take a beating without showing it. Its toughness, smoothness, resilience and excellent chemical resistance have already led to wide-spread use for things like chair arm pads, scuff guards, acid pails and golf bag tops.

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Men of Materials...

George Lubin, Director of Research, Bassons Industries Corp., is one of the pioneers in the development of reinforced plastics applications. His work in plastics began in 1936 with Columbia Records, where he worked on the development of electroformed molds and the use of Vinylite. During the war, Mr. Lubin headed the Plastics Control Group at the Naval Materials Laboratory, where he won commendations for developing methods and equipment for testing plastics materials. In 1947, Mr. Lubin joined Bassons where he has been responsible for many new developments and successful reinforced plastics products. He is a member of the Army-Navy Electronic Advisory Committee, the Plastics Committee of the ASTM, serves on the Policy Group of the SPI Reinforced Division, and is chairman of the Reinforced Group of the N. Y. SPE Chapter.

Lubin says . . .

"Laminators Have Know How, But Need Better Standards"

"In the first flush of growth, the lure of an easy process and low capital outlay attracted swarms of would-be manufacturers to the polyester-fiberglass laminate field. Unfortunately, from the sales bulletins of manufacturers, all that appeared necessary was a can of resin, a sheet of mat and a plaster mold. Then you were a low pressure laminator.

"Now most of the amateurs have departed—the financial losses they suffered would be difficult and painful to estimate—but the survivors are wiser for the experience. The major lesson learned is this: There are no bargain short cuts to quality parts and low production costs. To get results that provide necessary performance and remain competitive, good molds, good presses, and expert know-how is essential.

"A look at any of the successful production products in reinforced plastics—automobile bodies, washing machine elements, vacuum cleaner containers, tote boxes, luggage, aerial camera cases, and others—shows that inexpensive molds have been thrown out in favor of matched metal tooling. Fabricators and molders realize that precise production techniques are necessary if traditional materials are to be challenged on their own ground.

"Today, molders realize that while it is not necessary to approach the high pressures used in compression molding of thermosets, good positive pressure is necessary to insure a completely filled mold, and to eliminate bubbles and porosity. We are now using steel molds, and going about our business with confidence. However, aluminum and other low pressure molds have not been entirely eliminated—they have a distinct job to do in short run production and prototype jobs.

"As horizons expand and new products are launched, we in the reinforced plastics industry face an increasingly serious problem due to the lack of adequate standards. Our customers have every right to demand from us the same information on performance and tolerances that they get from fabricators of traditional materials.

"Right now, trade and professional groups are hard at work on the task of developing standards. This might be a propitious moment to express concern over possible duplication of effort. There is enough to be done so that every group can have its work cut out for a long time. A concerted effort should be made at this point to establish clear definitions of who does what—and when."

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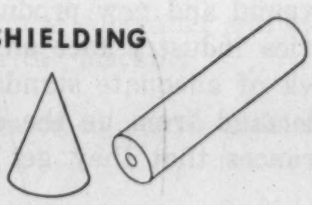

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Steel Prices Rise...

Across the board price increases for steel followed the 7½% increase in wages won by the steelworkers. The average increase in the cost of steel to consumers is 5.8% about $7.35 per ton, or a little less than ⅜¢ per lb. The price increases came as a shock to many steel users, who had expected a maximum increase of $4.00 to $4.50.

The increases, announced by U.S. Steel Corp., ranged from a minimum of $4.50 per ton for rolling quality carbon steel to a high of $17.00 per ton for cut lengths of electrical sheets.

In general the distribution of price increases seemed to reflect the relative amount of labor required to produce particular grades of steel. Many of the large tonnage items were increased $7.00 to $7.50 per ton—close to average—while spring wire went up $14 per ton.

Representative price changes:

Carbon steel products	Increase	Price per ton
Billets, forg. qual.	$6.50	$84.50
Billets, reroll	4.50	68.50
Tube Rounds	7.00	103.50
Hot rolled bars	7.00	93.00
Cold finished bars	10.00	118.00
Plates	5.50	90.00
Hot rolled strip	5.50	86.50
Cold rolled sheet	7.50	106.50
Galvanized sheet	8.00	117.00
Alloy steel products		
Ingots	4.00	69.00
Blooms billets slabs	10.00	96.00
Bar	9.00	113.00
Hot rolled strip	10.00	144.00
Cold rolled low crabon strip	10.00	125.00
Spring wire	14.00	155.00

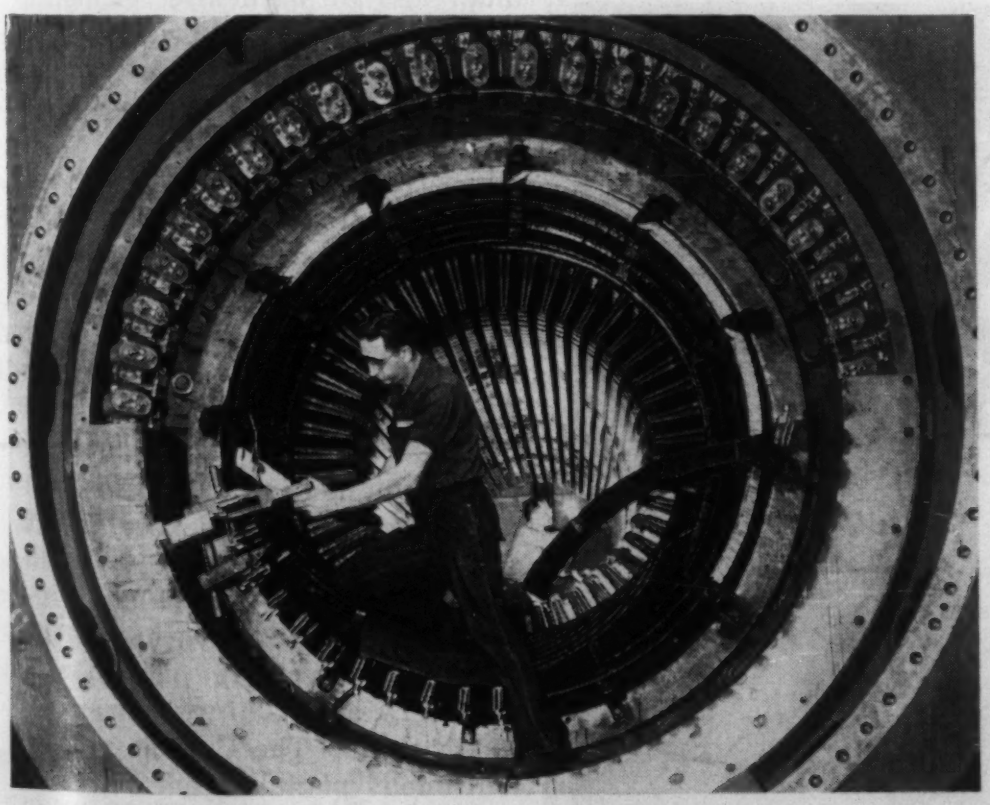
The new price schedules were first put into effect by U.S. Steel on July 6, but it will be some time before the effects of the price increases on manufactured goods are fully evident.

Clifford Hood, President of U.S. Steel, said that price increases were made necessary not only by the rise in employee wages, but by steadily mounting costs of purchased goods and services, state and local taxes, and of new construction. Hood pointed cut that during the last 15 years the hourly employment costs in the steel industry have risen 193% and the index of construction costs rose 170% while steel prices rose only 109%.

The demand for steel is holding up despite the price increases, as most steel purchasers were unable to build up extensive inventories of materials as a hedge against either a strike or a price increase, due to the extremely high rate of production during the first 6 months of 1955. The short steel strike, though it lasted only 12 hr, cost the steel industry much more than a day's worth of production due to shut-down and start-up of complex equipment.

Other steel producers followed U.S. Steel closely in their price revisions. Inland Steel's price increases were slightly lower, averaging about $6.10 per ton.

Product manufacturers are split concerning increasing prices for their products. Generally, those in tightly competitive markets, such as home appliances, intend to absorb the material cost increases without raising prices. Others, such as the automobile industry will pass on the increases with the new models to be introduced this Fall. The automotive industry had previously leaked hints that price increases could be expected next year, due to increased labor and material costs.

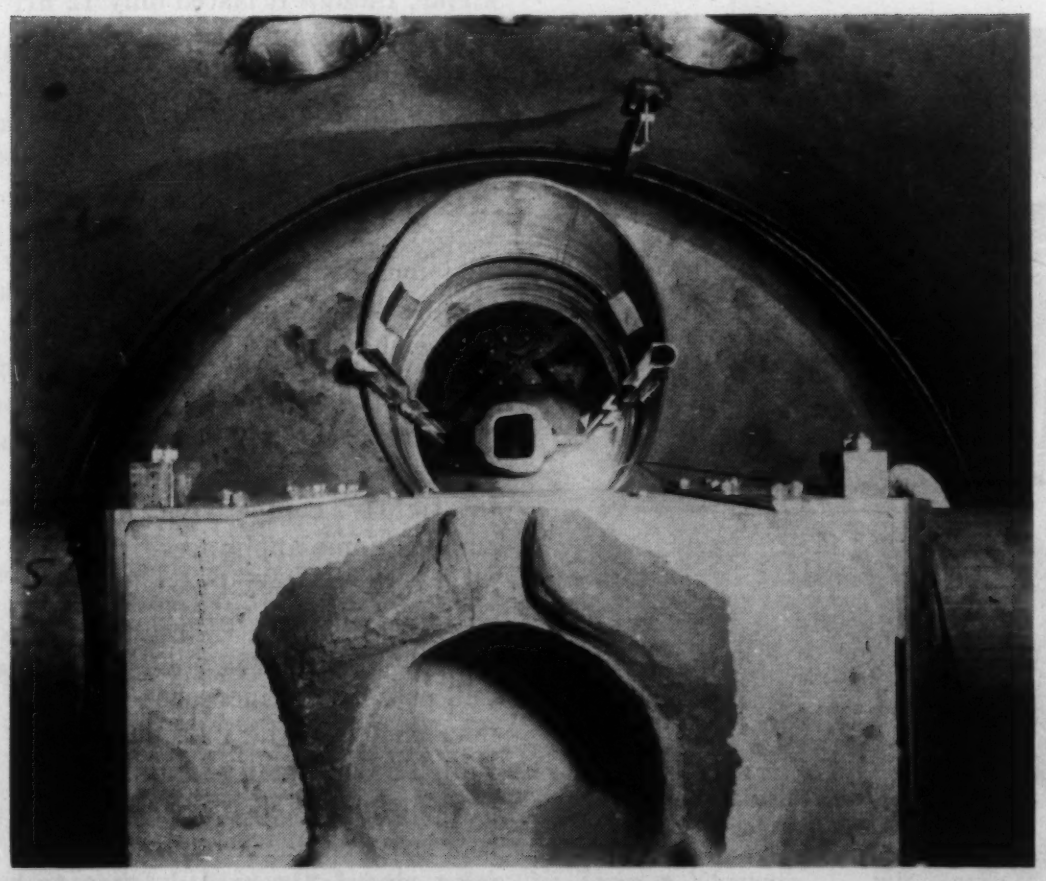


Liquid cooled stator *for 260,000-kv generator is first of its type. Circulating coolant through hollow stator windings allows generator to develop more power without increase in size.*

Melt can be adjusted, *material added from outside of vacuum furnace without breaking seal.*

Vacuum Melting Produces New Alloys

New pilot facility in production



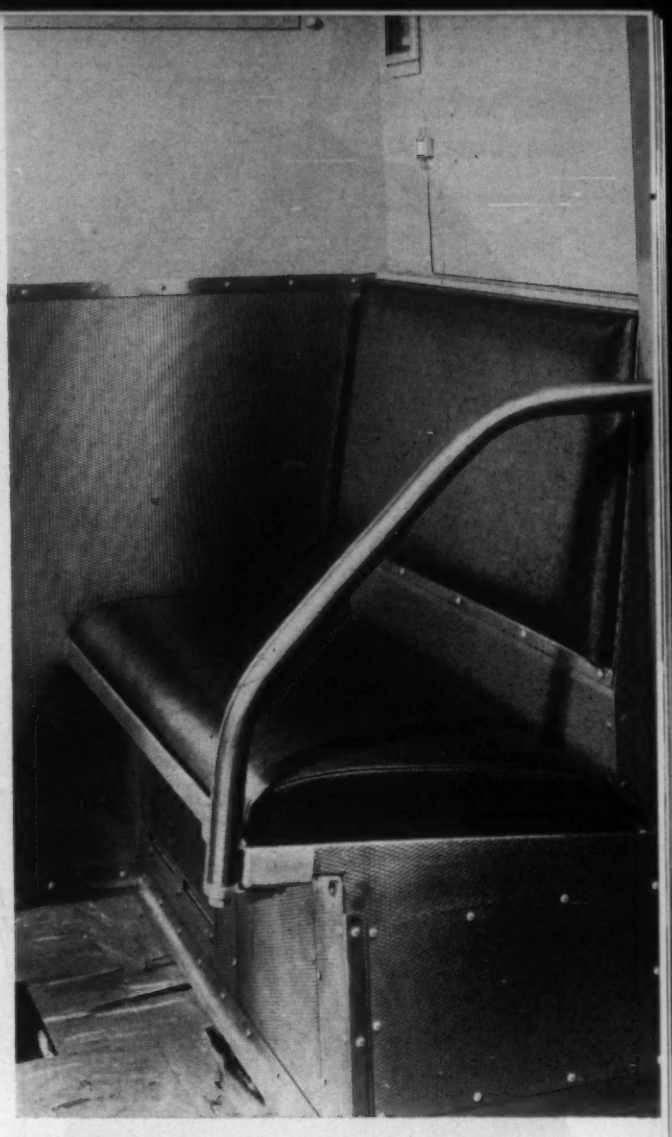
Crucible lip *is directly above ingot mold port. View shows part of ingot mold turntable.*

■ Vacuum melting, a technique that has been rushed into production to meet the demands of highly reactive metals such as titanium and zirconium, may find its greatest use in producing better versions of standard ferrous alloys. Only recently, Carboloy Department of General Electric placed a semi-continuous vacuum melting furnace in operation in Detroit. With a capacity of 120,000 lb per month, the new furnace will concentrate on producing high performance alloys that may well solve some of the problems associated with high temperature performance and longer lifetimes for parts such as bearings and gears.

■ Vacuum melting can improve alloys in a number of ways. The vacuum melted materials are substantially free of inclusions or impurities and have more closely controlled compositions. In some instances, vacuum melting fosters the development and production of a completely new family of alloys. For many existing alloys, properties due to vacuum melting are improved so markedly, that they too could be classed as new alloys. Nickel and cobalt base alloys, for example, benefit through vacuum melting because there is a minimum loss of hardening elements due to oxidation. Superior cleanliness is reflected in substantially improved fatigue and stress rupture properties. Ductility and overall workability are improved, resulting in fewer rejects. In addition, vacuum melted scrap has excellent remelt value. Vacuum melted metals often show simultaneous improvement in both ductility and tensile strength, according to Carboloy metallurgists.

■ Vacuum melting has progressed rapidly to larger and larger melt and ingot sizes. In 1950, 50-lb melts were rare. Now, 1000-lb ingots of titanium and vacuum melted steel are becoming common, and engineers are talking about 10,000-lb melts. The Carboloy semi-continuous plant is called a pilot unit, and it is capable of two 1000-lb heats per shift. The melt can be poured into ingots, casting or centrifugal casting molds.

New York subway cars *now being delivered, have vinyl foam seats.*



Vinyl-covered, *vinyl-foam subway seat.*

Foams Compete for Transportation Seating

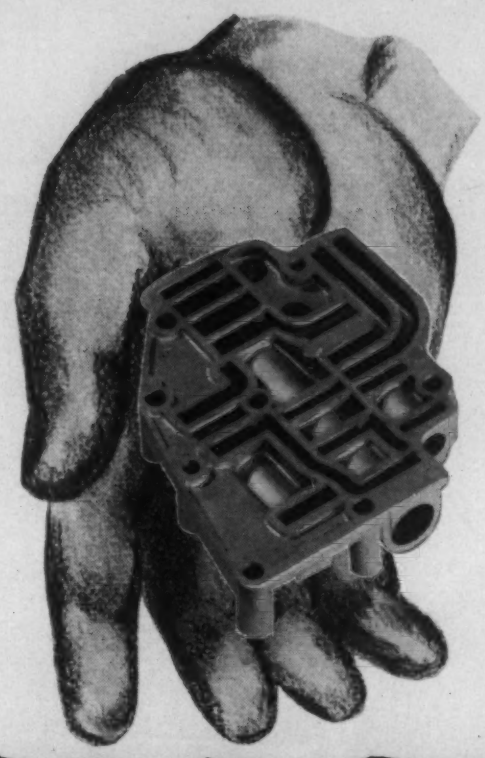
Railroad, bus, and streetcar manufacturers are keeping a sharp eye on the red, vinyl-covered foam cushions that are appearing in increasing numbers on New York City's subways. Under the colorful coated fabric are three different flexible foams. The one that turns in the best performance will be a long jump ahead of the others in the race for the largest piece of the lucrative industrial seating and upholstery market.

The three foams—two new and one old—are vinyl plastisol, polyurethane, and neoprene. Here is how the three materials rank at this stage of the year and a half old testing program:

■ **Neoprene.** Foamed neoprene enjoys the position of the most thoroughly proved fire resistant foam material. The U.S. Navy tested it for over ten years, and it proved out for use on combat vessels. It is suitably fire resistant, wears well, manufacturing facilities are available and ready with experienced manufacturers. But neoprene is too expensive at present when produced in the heavy foams necessary to take the rough abuse of public transit. According to New York's transit engineers, neoprene suppliers are making progress in developing lower cost formulations and lighter weight, tougher foams.

■ **Foamed vinyl.** Thick vinyl foams have only recently become available, but are rapidly assuming an important position in the seating and upholstery field. Credit for the development of practical

Interior of new subway cars *is brightened by red seats, vinyl tile flooring.*



No Magic Here

it took a lot of "know how" to produce

RIGHT from the very start of the design (which must be done with a thorough understanding of the problem and solution) to the delivery of the finished die casting to you, every step of production is controlled by a combination of factors . . . the hands of an expert, the watchful eyes of an inspector. Yes, each employee at Paramount is an expert in his field—fully trained in individual requirements for production, quality control and all other factors, so necessary to meet today's demands for skill and accuracy in the die casting process.

WRITE FOR THIS FREE BROCHURE

Here's the story of die casting and facilities at Paramount.

ALUMINUM ZINC MAGNESIUM

Paramount

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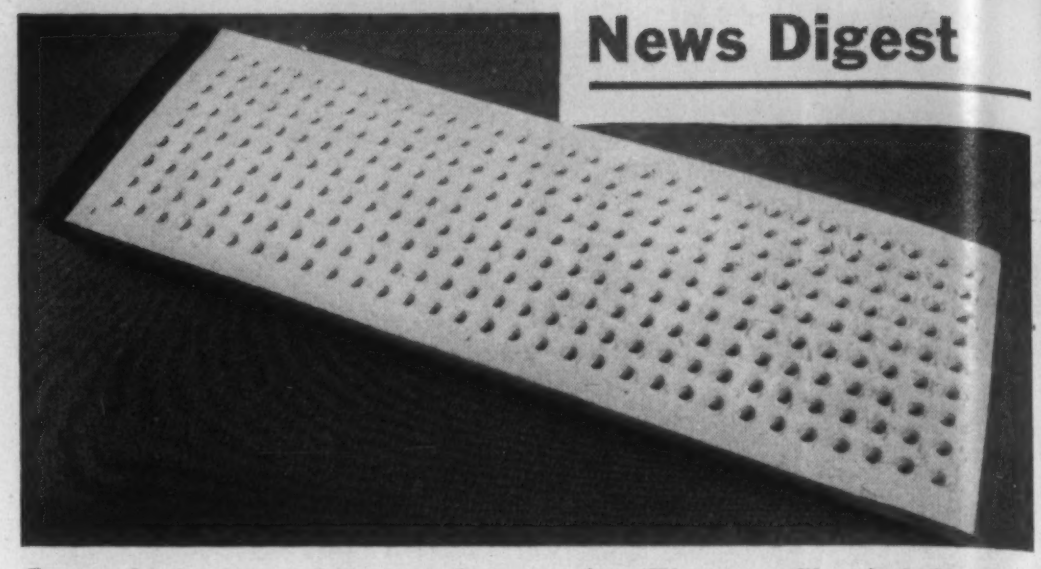
For more information, Circle No. 429

News Digest

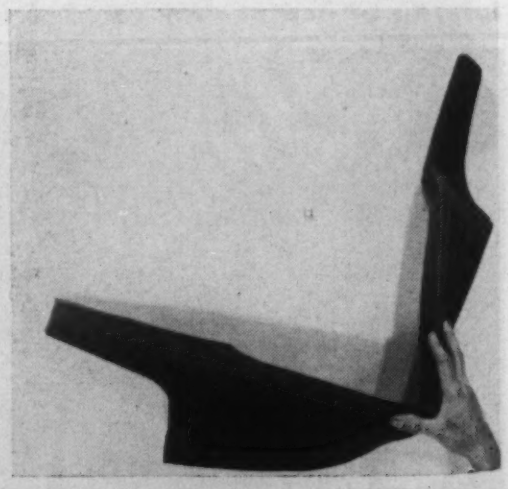


Foam vinyl core *used in new subway seating (Elastomer Chemical Corp.)*

plastisol foams goes to the Elastomer Chemical Corp. of Newark, which developed a top-notch, continuous-foam production technique using a high frequency cure. Foams up to four inches thick are now in production by a number of large producers working under Elastomer's license. Vinyl foams are in a favorable position from the standpoint of cost, are fire resistant, and can be formulated over a wide range of weights and resiliencies. Like polyurethanes, and unlike foam rubber and neoprene, the physical and mechanical properties of the foamed vinyls can be varied by changing the formulation of the material. Thus a dense foam can be either soft or hard, as can a relatively light foam. Lack of production experience is the one factor that is holding back the vinyls. The formulation and end product is satisfactory, but there is no long history of performance to offer as proof of the pudding.

■ **Polyurethanes.** These new foams show particularly good promise due to their high strengths at low densities. A test of polyurethanes in New York subway seating has been underway for a year and a half. The foams are turning in a good performance, according to preliminary reports, but have some unusual characteristics and a different "feel" that has caused some hesitancy in granting them complete approval. The outstanding characteristic of the foams now in use is called "bottoming". This does not mean that passengers end up sitting on the framework, but refers to a non-linear stress strain curve, which is in the shape of an ogive. The foam is resistant to slight pressure then compresses deeply until the "bottoming" point is reached. Then the foam exhibits greater resistance to further compression. The bottoming characteristic combined with a relatively slow speed of recovery from distortion give polyurethane foams a totally different feel than other types of seating. More than a difference in feel is holding up the polyurethane foams in industrial seating and institutional upholstery applications, however. The material is so new that manufacturing problems are still unsolved, some difficulty has been encountered with formulations, and it has been difficult to insure homogeneity in different batches of thick foams. The fastest progress is occurring in just this area of formulation standardization and manufacturing techniques, though, and within a short time most of the current difficulties will be solved—even competing foam manufac-

(Continued on p. 208)



***Integral-skin** foam vinyl crash pad for automobiles. (Elastomer Chemical Corp.)*

One point of view

Self-censorship won't work

Several months ago we expressed concern over the establishment of a type of "thought control" operation in Washington under the name of the Office of Strategic Information. Purported purpose of the bureau was to persuade editors to withhold information which could be of any use to a potential enemy. After some six months of ineffectual operation, the bureau was transferred to the Department of Defense where it now functions.

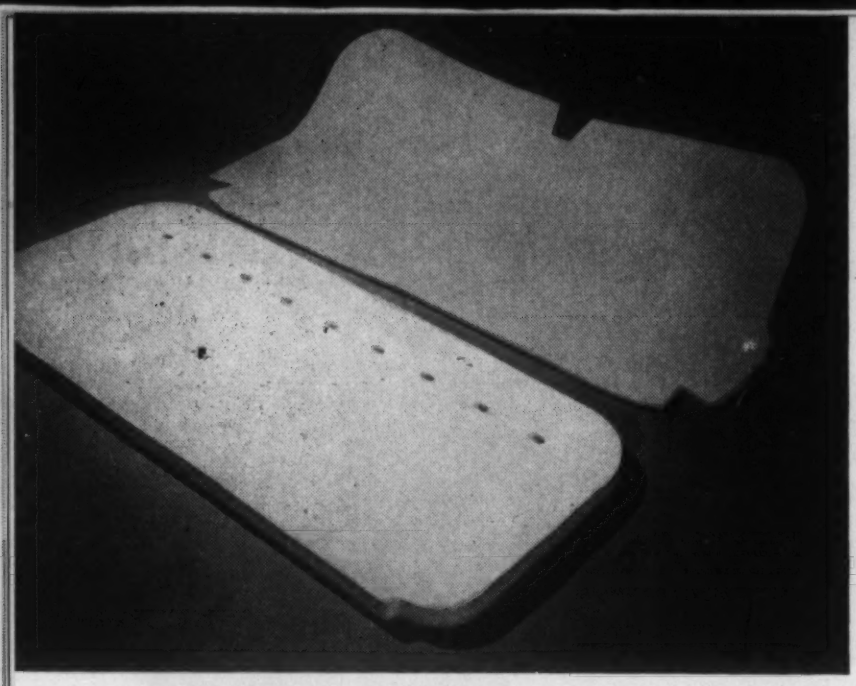
Now we can see the effects of the attempts to invoke self-censorship. Many news sources are drying up when the subjects they deal with have anything to do with military matters, whether or not the information involved might be critical. As we predicted, managements of companies are afraid to release non-classified information which might draw the wrath of Department of Defense officials.

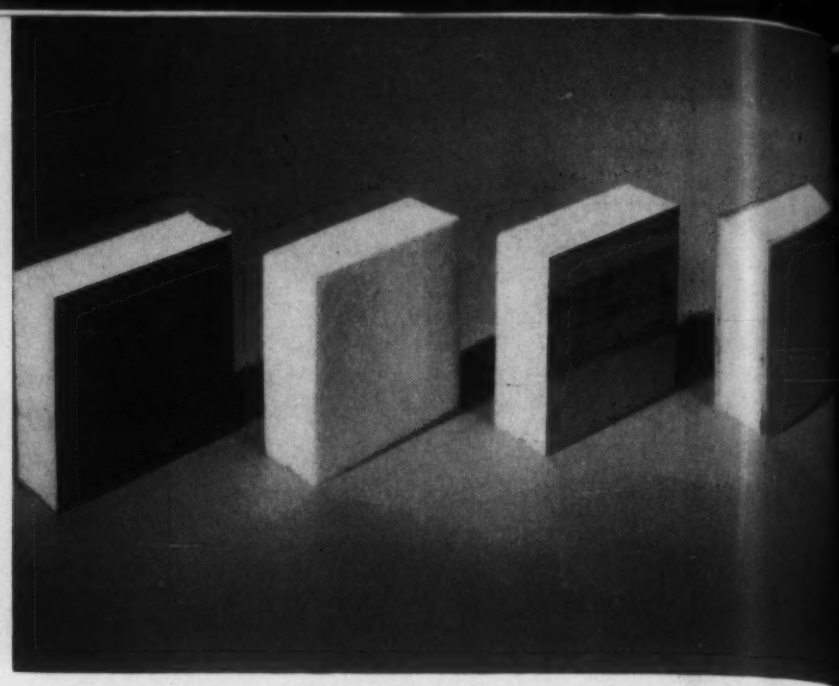
Aside from this real problem, the method of operation is stupid. Editors are supposed to draw up a "Balanced Sheet for Strategic Information." In using such a sheet, we are supposed to carefully scrutinize any information considered for publication. As a result of such scrutiny, an editor is supposed to determine whether the damage to our own people caused by withholding information is greater than would be the help provided to an enemy through publication. Such scrutiny is prescribed even when a roundup of previously published bits of information is considered.

As the publication, *Editor & Publisher,* states it: "It would be extremely naive to assume that the Kremlin does not have an organization sifting and analyzing and doing their own 'two plus two equals four' arithmetic."

The entire purpose and operation of this bureau seems stupid and unrealistic. As we said before, we can do more to harm ourselves as a country by cutting off the free flow of technical information than we could possibly help an enemy. If we haven't the ingenuity to keep ahead, secrecy certainly won't protect us.

J. C. Du Mond





***Polyurethane foams** are currently the most widely used isocyanate-base polymers. Left—flexible foam pads used in European car seats and backs. Right—sandwich structures made by forming rigid foam between panels of plywood, plastic laminate, veneer and aluminum, respectively.* *(Mobay Chemical Co.)*

The Isocyanate-Base Polymers—

Rigid and flexible foams are biggest present applications. Others in use or on the way are elastomers, coatings, potting compounds, adhesives, greases and heat resistant plastics.

by Irving Katz, *Research Engineer, North American Aviation, Inc.*

■ Isocyanate-base polymers are relatively new materials that are structurally similar to nylon. They include the polyurethanes, the polyureas and the polyamides. These are made by adding isocyanates to hydroxy, amino and carboxyl compounds, respectively.

Isocyanate-base polymers were developed originally by Germany's I. G. Farben about 1937 and are relatively widely used in Europe. Interest in this country stemmed from reports prepared by Allied industry-investigating teams following World War II. Now an increasing number of development programs on these materials are being undertaken. This article is a brief review of developments in elastomers, adhesives, potting compounds, expanded plastics, heat-resistant plastics and greases.

Elastomers

Two isocyanate-base elastomers are being developed: isocyanate-modified polyesters and internally plasticized polyurethanes.

Modified polyesters—These elastomers are flexible and have unusual abrasion resistance. They have good resistance to ozone and general weathering, excellent oil resistance, and fair resistance to dry heat. Under moist heat (212 F), however, they break down rapidly. They have poor resistance to aromatics, chlorinated hydrocarbons, ketones, substituted ammonium compounds, terpenes, acids and bases.

Potential applications include shoe soles and heels, hydraulic gaskets, oil seals and timing gear belts. Present manufacturing costs are too high for most commercial applications. However, it has been conjectured that tires having tread lives of 100,000 miles could be made from these rubbers at prices competitive with those of other rubber-base tires of comparable road life. These elastomers also show promise as wear-resistant, weather-resistant coatings.

Isocyanate-modified polyesters are made by a three-step process: 1) reacting polycarboxylic acids with excess polyhydroxy compounds to form a hydroxy-rich polyester, 2) reacting the polyester with excess polyisocyanates to lengthen the polyester chain molecule by means of polyurethane linkages, and 3) reacting the modified polyester with water, glycol, diamines or additional polyisocyanates to cure or vulcanize the rubber.

Although the uncured rubber has a shelf life of several weeks, the rubber when compounded with the vulcanizing ingredients has a drastically reduced shelf life of only about one day. Hence fabricators must do their own compounding immediately prior to molding. Preliminary information indicates that the green rubber may be broken down and compounded in a Banbury, and the final curing agents may be added on a cool mill.

Other indications on compounding: 1) plasticizer additions act only as quality diluents, 2) soften-

Flexible foam *can be fabricated with simple tools. Here a seat cushion is made by (1) slicing a sheet of polyurethane foam with a horizontal saw, (2) shaping it with a band saw, (3) coring it with a circular saw, and (4) joining the cored block to another polyurethane foam pad with an isocyanate cement.* *(Mobay Chemical Co.)*

a new family of engineering materials

ing agents have a pronounced initial softening effect but tend to accelerate undesirable hardening of cured stock, and 3) carbon blacks do not improve toughness except in certain weak stocks.

The compounded rubbers have little or no building tack; temporary tack may be imparted by treating the stock with ketones such as acetone or methyl ethyl ketone. The compounded rubbers also have poor adhesive qualities. Successful bonding to other rubbers requires a blend of the isocyanate-modified polyester and the other rubber to be bonded.

Polyurethanes — These internally plasticized elastomers are water-white transparent materials having extensibility, toughness, stability to light and heat, insensitivity to water and good adhesive qualities. They have a great affinity for glass; certain compositions bond so firmly that the glass fails in preference to the bond. Potential uses include specialty casting resins, optical cements and interlayers for specialized safety glass applications.

Polyurethane elastomers are made by copolymerizing mixtures of polyhydroxy compounds and hydroxy-rich plasticizers with either pure isocyanates or isocyanate prepolymers. The reaction occurs at room temperature and is especially rapid for low plasticizer concentrations. Presence of moisture or acids must be avoided since they react with isocyanates to produce carbon dioxide and thereby cause blistering. Standard casting techniques are satisfactory. Properties of the end material are enhanced by a short postcure.

The elastomers may be varied from hard, tough, horn-like solids to soft, tacky semi-solids by varying the concentration of plasticizer. The more highly plasticized materials have a relatively low temperature limit. A modification with hydroxy-rich polyesters shows improved heat resistance but lower elastomeric properties.

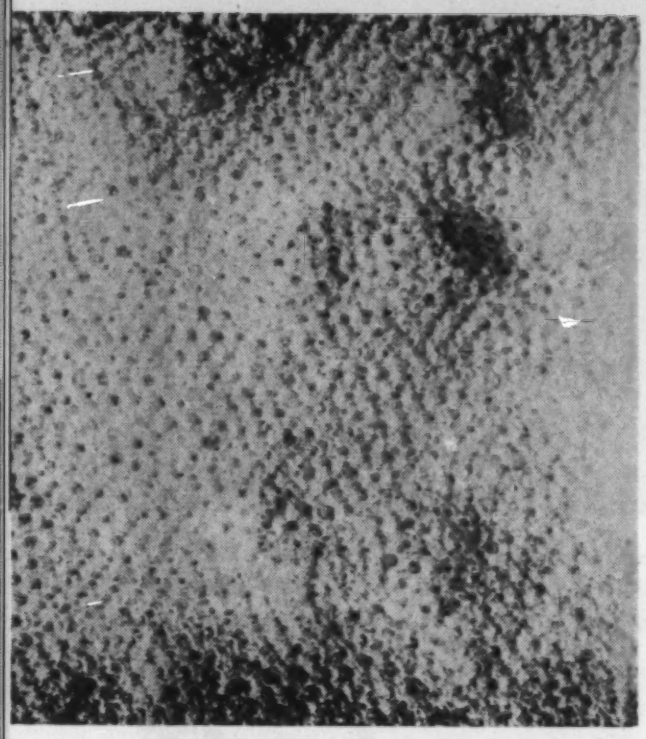
Optical properties of the cured rubbers are partly dependent upon the initial color of the reactants, and purification is essential for a colorless end material. Extent of purification needed will be an important factor in determining future cost of these elastomers.

Adhesives

Isocyanates now make it possible to structurally bond materials with a low-temperature, fast-curing adhesive. The three basic types of isocyanate adhesives, for want of better names, can be classified as polyurethanes, hybrid polyurethane - polyureas, and polyisocyanates.

Polyurethanes—These adhesives have limited pot life and are generally prepared only by the fabricator at time of use. Weighed amounts of polyhydroxy compounds and polyisocyanates or isocyanate prepolymers are mixed and applied to the surfaces to be bonded. The parts are assembled and the bond is allowed to cure at room temperature under contact pressure; for some compositions an afterbake under pressure is beneficial. A modification that employs solvents such as acetone or methyl ethyl ketone provides some latitude in pot life but requires a drying period and a higher-temperature cure.

Although this type of adhesive combines the advantages of a rapid cure at low temperatures with the absence of polymerization by-products, it requires careful handling of the potentially-dangerous isocyanate, rather accurate weighings and tight production schedules. Despite these disadvantages, this type of adhesive can be used for general-purpose bonding and has shown some promise for



Cell structure *of isocyanate-base expanded plastic shown by photomicrograph.* *(Nopco Chemical Co.)*

metal-to-metal bonding in extreme-low-temperature applications.

Polyurethane-polyureas—These hybrids are more attractive than the straight polyurethanes because they have much longer pot life and need not be prepared by the fabricator. They are made by reacting polyhydroxy compounds with an excess of polyisocyanates to produce isocyanate-rich polyurethanes. Curing occurs when the moisture in the air converts part of the excess isocyanates into amines and liberates carbon dioxide. The carbon dioxide escapes more or less readily from the open-face adhesive-coated surfaces. (A solvent addition provides a lower-viscosity adhesive and facilitates release of the carbon dioxide, but it also seems to reduce the shelf life of the adhesive.) The amines react immediately with the excess isocyanate to form polyureas which, in turn, crosslink the adhesive by reacting with the remaining isocyanate.

In practice, the adhesive is applied to the surfaces to be bonded and allowed to remain exposed to air for a predetermined period. The parts are then assembled and the bond cured under pressure. A relatively short room-temperature cure is permissible, although some heating may give optimum bond properties. Although these adhesives are easier to use than the straight polyurethanes, they must be handled with considerable care to prevent undue moisture contact resulting in premature gelation.

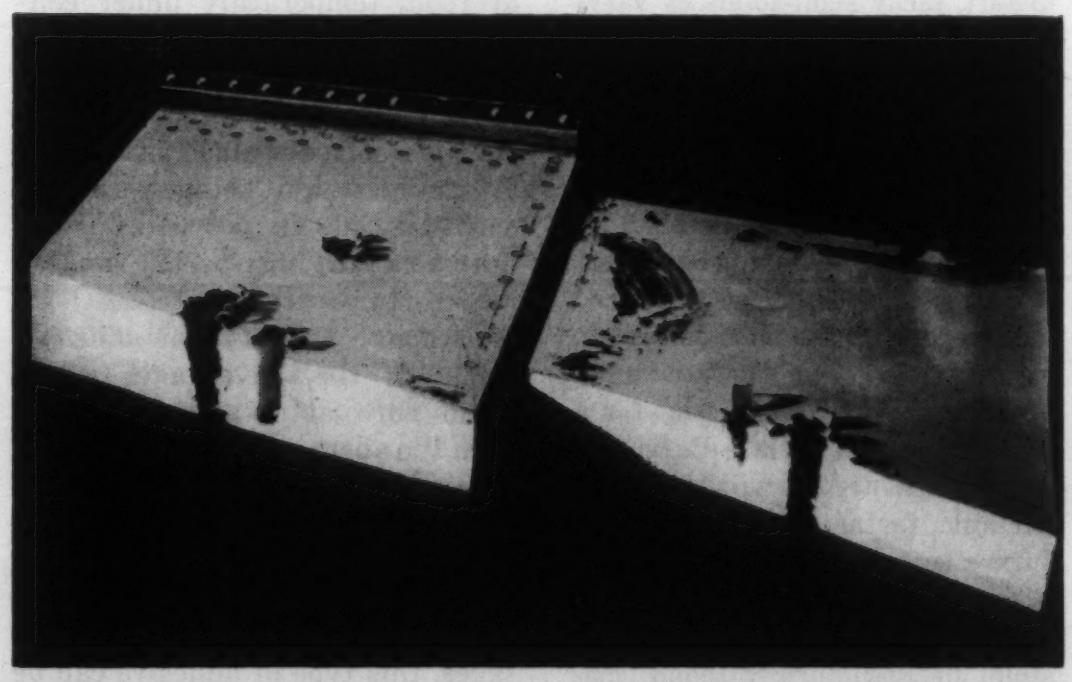
These adhesives are suitable for bonding practically any combination of materials. Bond properties vary with differing types and ratios of ingredients and catalysts. Since there has been little standardization of basic formulations, fabricators must generally develop their own formulations.

Polyisocyanates — Alone or blended with rubbers, isocyanates have received much attention as adhesives for bonding rubbers to metals and fabrics. Present development work indicates they may be more versatile than the adhesives based on rubber derivatives or the earlier brass plating and ebonite layer techniques. They can bond practically any combination, they are easily applied, and they provide bonds with good oil and solvent resistance and good mechanical properties. The bonds have excellent flex resistance. Bonding techniques are analogous to those used with hybrid polyurethane-polyurea adhesives, the curing mechanism being essentially the same.

Bond strength is affected by the length of the open-standing period and the ambient humidity. Preliminary tests indicate that the open-face period for the straight polyisocyanates should be relatively short, say on the order of hours. However, tight production scheduling can be avoided in two ways. Cover cements based on the elastomer to be bonded can be applied to the adhesive-coated metal parts. Or, adhesives that are blends of polyisocyanates and elastomers may be used instead of straight polyisocyanates to lengthen the allowable open-face period. However, the blends themselves have shelf lives generally limited to one week, although stability can sometimes be improved by solvent additions.

Blends are made by breaking down the rubber on a mill, preferably with a peptizing agent, dissolving the masticated rubber in a solvent and adding the isocyanate. The cement is usually stored at room temperature for a few hours prior to use. Because of the limited pot life, the fabricator must formulate his own blends.

Dilute solutions of blends can be used to bond elastomers to fabrics. The fabric is coated with the adhesive, the solvent allowed to evaporate, the elastomer applied to the coated fabric, and the assembly cured under contact pressure.



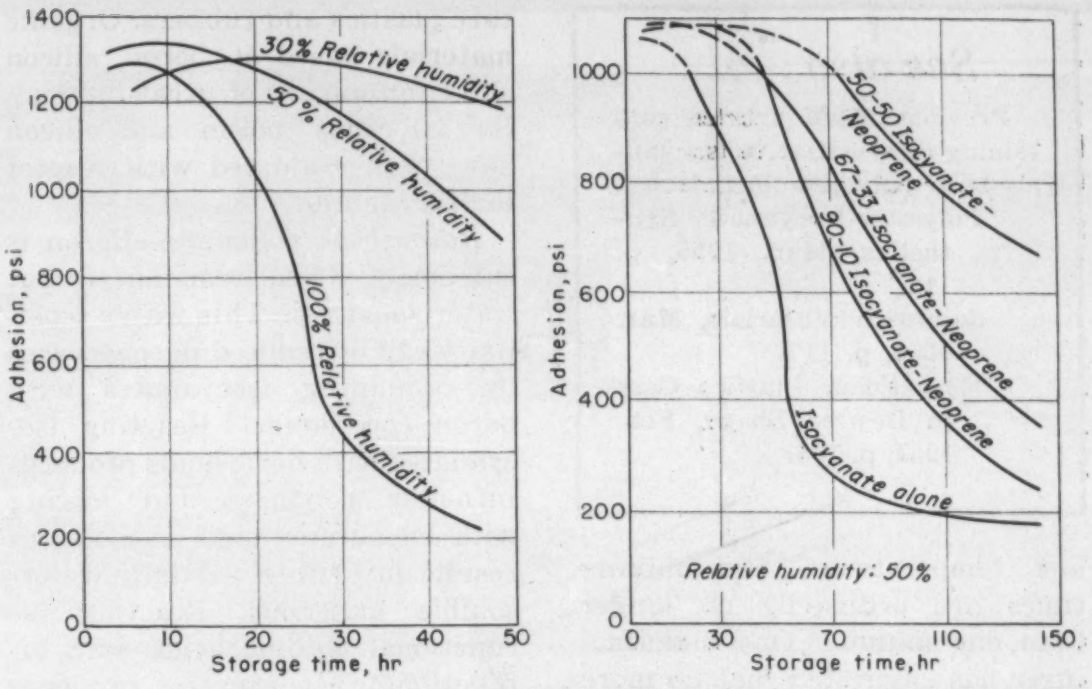
Bond *between foamed plastic core and outer aircraft skin stands up under impact of 50-caliber bullets.* *(Lockheed Aircraft Corp.)*

Potting compounds

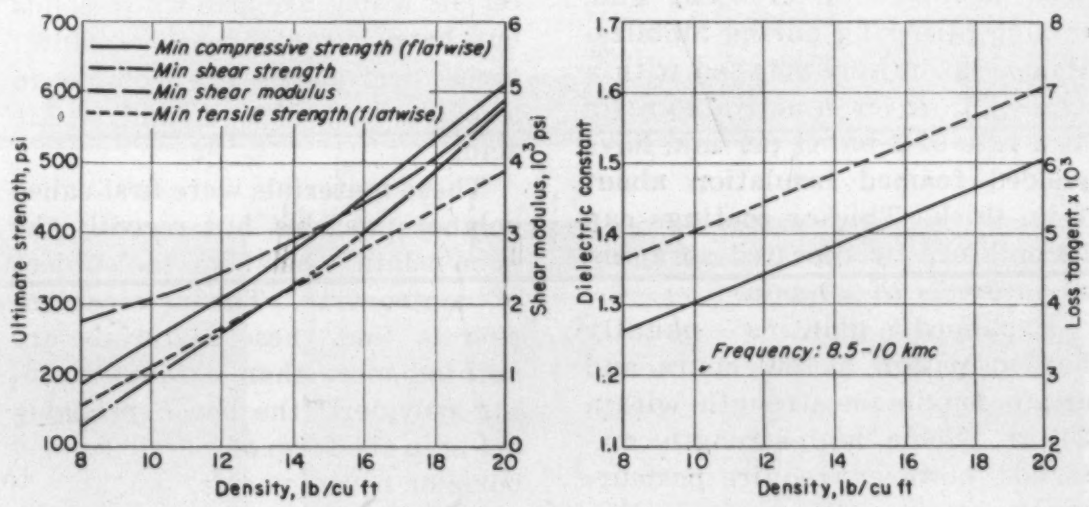
There is a continuing search for potting materials that have low water permeability, low

shrinkage, stability through wide temperature ranges, good mechanical properties, elastomeric properties and good resistance to chemicals, particularly ionic types such as salt water. Such a plastic is particularly useful if it also combines low dielectric constant and low dissipation factor with high dielectric strength and high resistivity. It has been recognized that isocyanate-base polymers might have undesirable electrical properties because of their polarity. Castor oil appears to be a compounding ingredient capable of reducing polarity to a minimum. In addition, the castor oil molecule contains three reactive positions which, if utilized, produce a thermosetting polymer with characteristically improved thermal and chemical properties; and castor oil also imparts elastomeric properties to the plastic by internal plasticization.

Castor oil-modified polyurethanes that conform to MIL-T-27 requirements for transformer potting compounds have been developed. However, they may not be satisfactory for high-frequency potting applications where a dielectric constant of less than 3.5-4.0 is needed. On the other hand, they are potentially suitable in other high frequency applications such as phase shifters in radar wave guides. By increasing their loss factor, they can be made suitable for termination or dummy loading of microwave power.



Left—how humidity and storage time affect the adhesion of a polyisocyanate adhesive to steel. Right—how blending with an elastomer affects the allowable storage time of a polyisocyanate adhesive to be applied to steel. (Both charts adapted from a duPont report, "Bonding Elastomers to Metals with MDI-50", BL-241, Apr. 1951).



Mechanical and electrical properties required of foamed-in-place core materials by MIL-C-8087 (USAF) when tested in sandwich form at room temperature.

Expanded plastics

Although a moist or acidic environment often means trouble with isocyanate-base materials, the isocyanate materials most widely used today are made by deliberate, though carefully controlled, additions of water and/or acid. Such additions cause the resin to undergo a considerable increase in volume—as much as 30-fold—during cure. The result is a plastic composed of a multitude of randomly distributed cells. This expanded material is lightweight and resilient, and it has good mechanical, electrical and thermal-insulating properties.

The foaming mechanism is a two-step process. The isocyanate-rich resin reacts with water, liberating carbon dioxide and forming polyurea linkages which, upon further reaction with excess isocyanate, crosslink the resin. As polymerization continues, the resin becomes more viscous and is swelled in volume by the entrapped carbon dioxide. By varying the ingredients, it is possible to control the final density, to produce materials of equal density ranging from soft and flexible to hard and rigid, and to produce either mainly open-cell or mainly closed-cell materials.

Expanding resins are used in two ways. They may be prefoamed in a mold, then assembled, or they may be foamed within the assembly itself. Bond strength of foamed-in-place assemblies can be improved somewhat by first flushing the surfaces of the part with isocyanates. However, bonding is usually no problem and good bonds have been reported even in foaming against wet surfaces.

The chemical reaction starts as soon as the components are mixed. Most commercially available foaming resins require no preheating unless they have been stored at

See also . . . . .

Previous M&M articles containing information on isocyanate-base polymers include:

Polyester-Isocyanate Synthetics, Mar. 1955, p. 112.

Sandwich Materials, Mar. 1954, p. 117.

New Foam Plastics Cast to Desired Shape, Feb. 1953, p. 108.

low temperatures, and mixing times are ordinarily no longer than one minute. One manufacturer has suggested that no more than 10 lb of material be processed at one time. Where large quantities are handled, it may be necessary to inject the mixture into the part under pressure.

In certain applications, the foaming plastic may be sprayed from a two-container spray gun, mixing occurring during atomization. Flat objects sprayed with a 1/16-⅛ in. layer of activated resin at a rate of 3 bd. ft per min have yielded foamed insulation about 1 in. thick. Thicker coatings can be obtained by repeated spraying at intervals of 30 min.

Expanded plastics usually harden within a few hours and attain maximum strength within 24 hr. Some high-strength materials, however, require postcuring to attain optimum strength.

Rigid foams are being used in sandwich constructions to provide greater skin stabilization in aircraft, thereby permitting higher-stress design. Flexible foams are being investigated for encapsulation of electronic equipment where protection against severe vibrational shock is needed. Use of the insulating foam in refrigerator truck bodies is also being studied. Isocyanate sponge materials (open-cell), only about one-half the density of foam rubber, are finding use as carpet underlays, shoulder pads, furniture padding and cleaning sponges.

Heat-resistant plastics

Much work is being done on the development of high-temperature plastics and rubbers. Organic materials based on boron, silicon and titanium are of great interest. So far, only boron and silicon have been evaluated with respect to isocyanates.

Boron-base polymers—Boron is extremely heat-resistant, but water sensitive. This water sensitivity can be reduced in some cases by combining isocyanates with boron compounds. Reacting isocyanates with boric acids produces infusible polymers, but mixing with monofunctional isocyanates results in fusible, partially water-soluble materials. Reacting bifunctional boronic acids with bifunctional isocyanates produces white solids having high softening points and melting points at 600-630 F. These polymers can be made into films and fibers and are soluble in phenol, formic acid, benzene and ether. They can be converted to more elastomeric materials which are also white solids but have lower softening points; these derivatives are soluble in alcohol, formic acid and acetic acid.

These materials were first called polyboronamides, but recently the nomenclature has been the subject of controversy. The new contention is that these materials are nothing more than boron-containing polymers, the boron probably being in the form of loosely bonded boric or boronic acids.

Silicones—A chief drawback of silicone resins is their softening at elevated temperatures. Silicone copolymers made by reacting silanediols with diisocyanates are infusible and insoluble, and they have decomposition temperatures in the range of 675-750 F. Some adhesives made from such resins have shown metal-to-metal bond strengths of about 500 psi at 500 F. Materials that withstand temperatures on the order of 600 F and may have elastomeric properties can be made by reacting silicon-base polyisocyanates with carbon-base polyhydroxy compounds.

Isocyanate Suppliers

E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

The Garwin Co., North Haven, Conn.

Mobay Chemical Co., St. Louis, Mo.

Monsanto Chemical Co., St. Louis, Mo.

National Aniline Div., Allied Chemical & Dye Corp., New York, N.Y.

Other uses

Greases that will operate over increasingly wider ranges of temperatures and loading are needed. Such greases must not melt, harden or darken excessively at elevated temperatures; must not thicken excessively at low temperatures; should have good mechanical stability throughout the intended temperature range; and should have low evaporation and leakage losses.

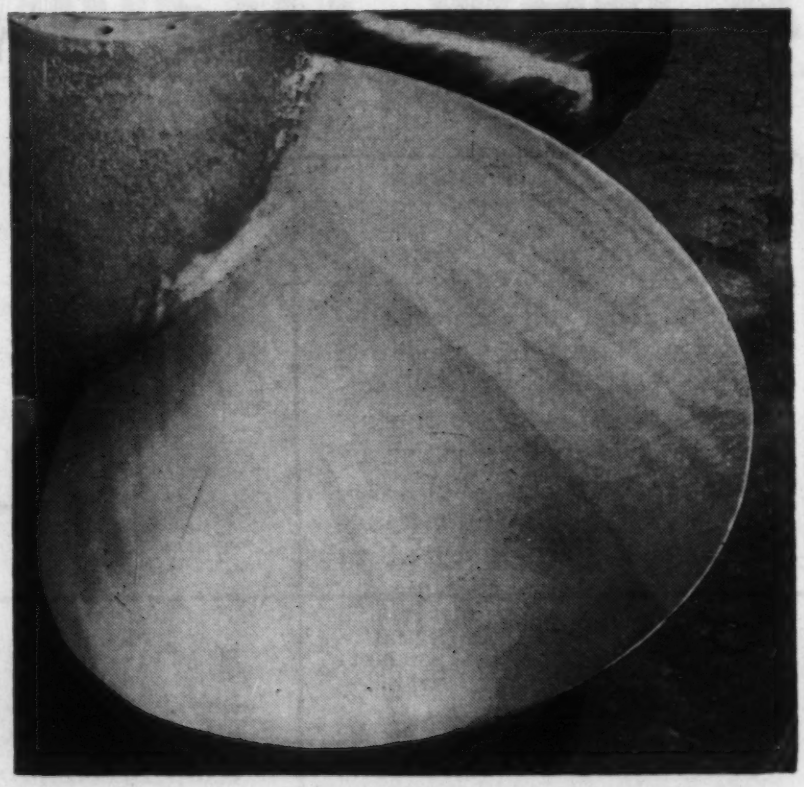
Because of their excellent temperature stability and good lubricity, silicone fluids are a good base for such greases despite their poor wear properties. Current investigations of both organic and inorganic thickeners indicate that the isocyanate-base ureas are the most promising for high-temperature greases. Silicone fluids thickened with these ureas are stable and have good rheological properties, but suffer from poor wear and low-temperature properties. The amides are not as satisfactory as the ureas, and the urethanes have not been sufficiently evaluated.

Other isocyanate-base products under development or investigation include molding compounds, protective coatings, textiles, laminates (to a limited extent), rocket propellants and resin catalysts. The catalyst development has resulted in so-called "isocyanate generators"—compounds which can be used to modify the base resin in an epoxy adhesive, for example, so that the catalyzed resin will not start to cure until a slightly elevated temperature is applied.

This article is based on a paper given at the 1955 annual meeting of the Society of Plastics Engineers and published in the SPE Journal.

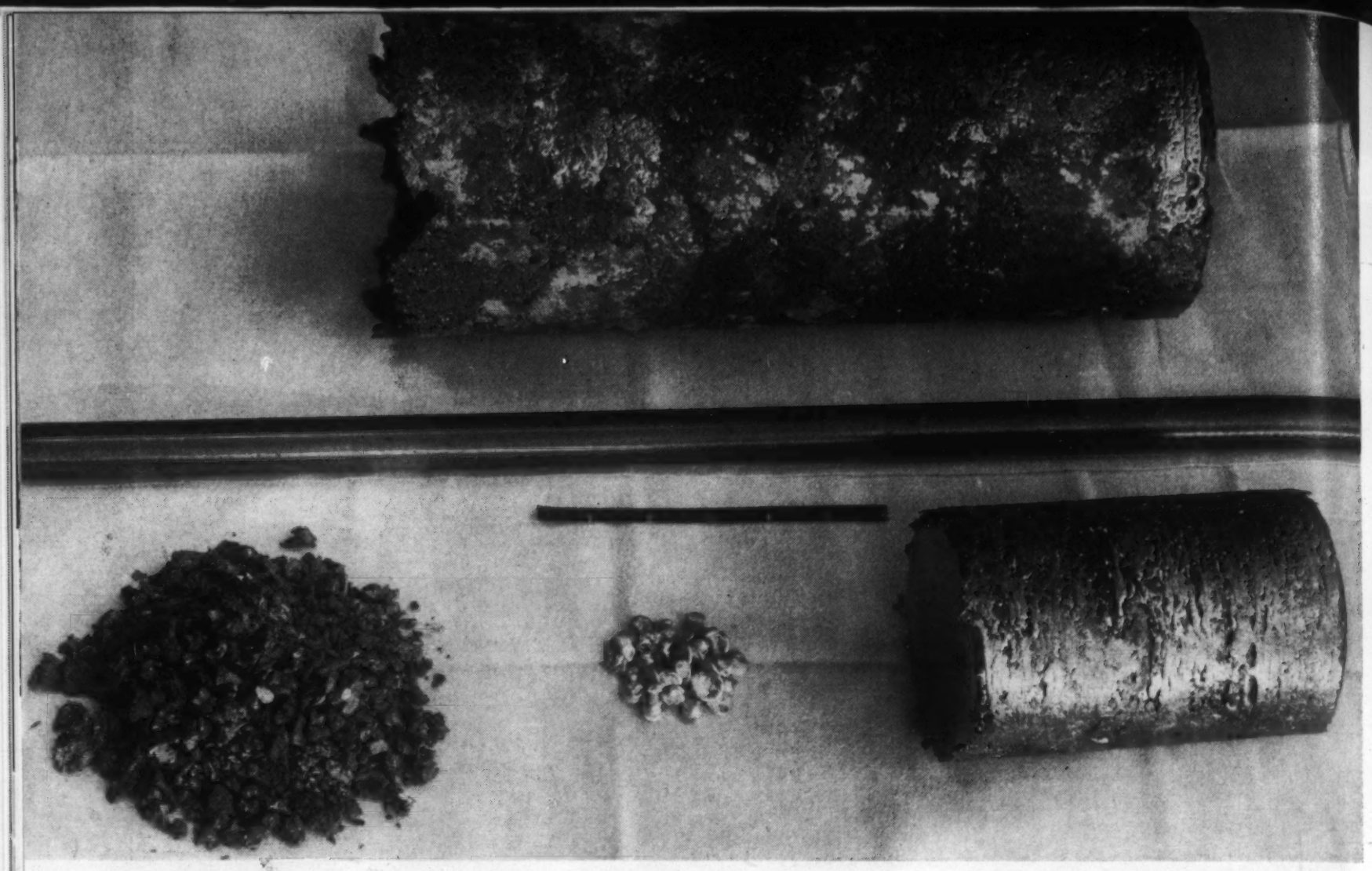
Materials at Work

New and old materials in unusual applications



Stainless Steel Repairs Propeller Stainless steel wire is here being used to build up and replace a pitted surface on a 102-in. nickel-vanadium steel propeller. Using Aircomatic welding methods developed by Air Reduction Co., the Coolidge Propeller Co. applied 312 lb of welding wire to clad the 15,552 sq in. of the propeller. Welding began on the thin edge of each blade and progressed, small areas at a time, to the hub. Each blade was worked on alternately to distribute heat evenly. After total deposit was laid, the propeller was straightened, repitched, balanced, and the surface ground, providing smooth, corrosion resistant blades.

(Additional Materials at Work on p. 93)



Titanium alloys *are produced with these materials: titanium sponge and, the alloying element. These are melted in a non-consumable electrode furnace to produce ingot at (right), which is forged into rod (right rear). Rod becomes electrode in consumable-electrode furnace to produce large ingot (rear).* *(Armour Research Foundation)*

A New Titanium Alloy

Available now as forgings, bar, plate and sheet, this aluminum-vanadium-titanium alloy has—

- *Usable strength up to 1000 F*
- *High tensile and impact strengths*
- *Good weldability*

by R. J. McClintick, G. W. Bauer, and L. S. Busch,
Mallory-Sharon Titanium Corp.

■ MST 6Al-4V is a weldable alpha-beta titanium bar and sheet alloy which has excellent elevated temperature properties and can be heat treated to very high strengths. The combination of good mechanical properties in general, a high hydrogen tolerance (greater than 240 parts per million), low density and availability in all basic shapes such as forgings, bar, plate and sheet make the alloy a promising structural material for widespread use in airframe, jet engine and ordnance applications. In bar form, its elevated temperature and fatigue properties suggest applications in compressor parts for jet engines. In plate form, its good impact, high heat-treated strength and weldability indicate its suitability for armor plate. And in sheets, its strength and weldability are attractive for applications not

What is MST 6Al-4V?

This alloy was developed by Armour Research Foundation under contract with Watertown Arsenal, and subsequently developed for production by Mallory-Sharon Titanium Corp. The titanium-aluminum-vanadium system is of the beta isomorphous type, showing no eutectoid decomposition. In bar form, the alloy generally contains no more than 10-20% beta phase and even less in sheet form. However, enough beta can be retained by quenching from upper portion of alpha-beta field that subsequent aging at lower temperatures produces strengths up to 200,000 psi level. Commercial production was announced in April issue of M & M.

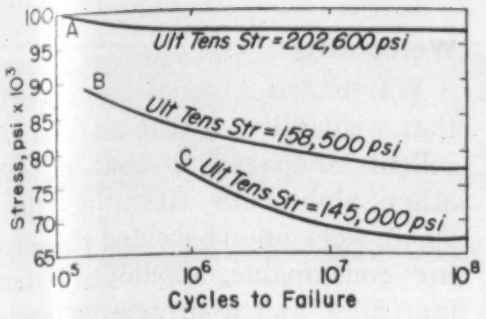


***Fig 1** Effect of various heat treatments on fatigue of ⅝-in. dia bars of MST 6Al-4V.*
A: 1850 F, ½ hr, WQ + 900 F, 1 hr, AC.
B: 1600 F, ½ hr, AC.
C: 1850 F, ½ hr, FC to 900 F, AC.

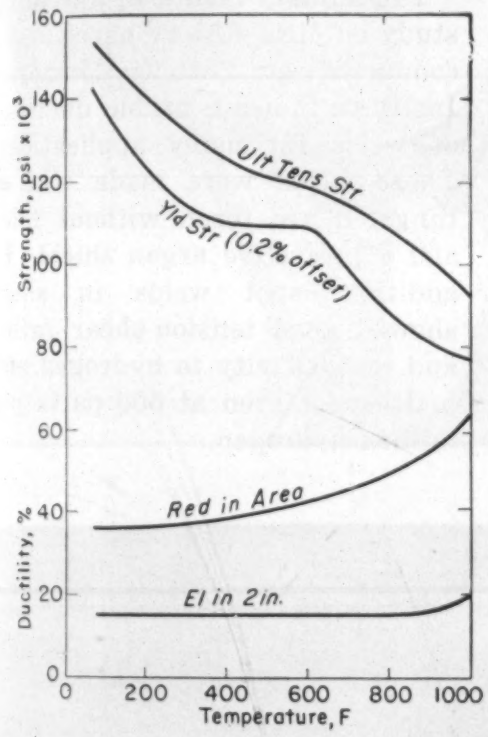


***Fig 2** Tensile properties vs temperature for MST 6Al-4V. Tests run by Pratt and Whitney Aircraft, Div. of United Aircraft Corp.*

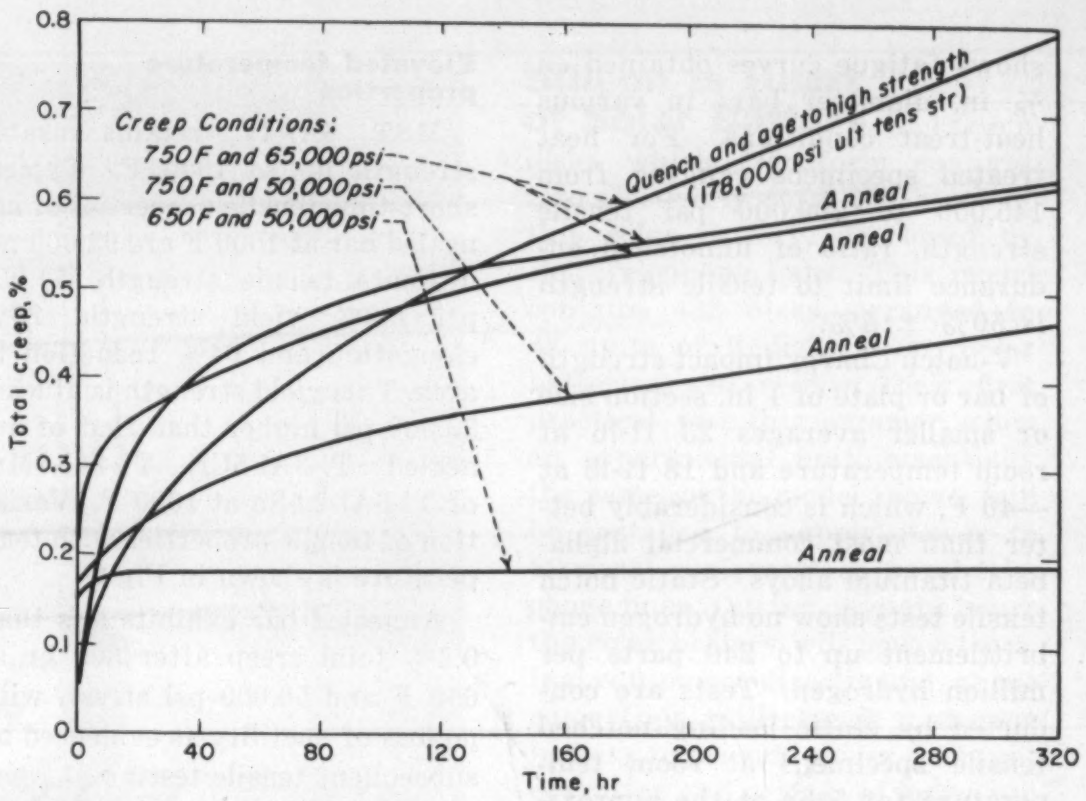


***Fig 3** Creep of annealed MST 6Al-4V alloy in ⅝-in. dia bars, and effect of heat treatment on creep.*

TYPICAL PROPERTIES OF MST 6Al-4V
(Room Temperature)

Nominal Composition	6 Al, 4 % V, bal Ti
Density, lb/cu in.	0.160
Coef of Therm Exp, micro-in./°F:	
at 90-932 F	5.2
at 932-1652 F	5.8

	Cond A[1]	Cond B[1]	Cond C[2]	Cond D[3]
Ult Ten Str, 1000 psi	149	164	198	155
Yld Str, 1000 psi	137	153	180	130
Elong in 1 in. for bar, 2 in. for sheet, %	13	13	9	12
Red in area, %	39	40	31	—
Hardness, Rc	30	33	38	37

[1] Values obtained on rolled or forged stock in sections from ½ to 3 in.
[2] Values obtained from ⅝-in. bar.
[3] Values obtained from 0.020-0.090-in. sheet.
Condition A; 1500 F, ½ hr, AC (FC section sizes under ⅝ in. to 1100 F).
Condition B; 1400 F, ½ hr, WQ + 1100 F, 8 hr, AC.
Condition C; 1700 F, ½ hr, WQ + 900 F, 2 hr, AC.
Condition D; 1450 F, 2 hr, FC to 1100 F, AC.

requiring sharp bend radii. The high beta transformation temperature of 1800 F minimizes possibility of beta embrittlement due to overheating during fabrication.

Heat treatment vs mechanical properties

A table shows typical physical and mechanical properties of MST 6Al-bV. Tensile properties between 145,000 and 200,000 psi ultimate can be produced by properly adjusting heat treating conditions. Increasing solution heat-treat temperatures from 1400 to 1800 F, and decreasing aging temperatures from about 1200 to 800 F increases strength and lowers ductility somewhat. Best combinations of high strength properties are obtained by aging for 1 to 24 hr, depending on temperature. Longer times are required at lower aging temperatures and shorter times at higher aging temperatures to gain the best ductility commensurate with a given strength level.

Bar and forgings can be softened by annealing between 1300 and 1500 F for ½ to 1 hr and air cooling. Annealing at 1300 F provides about 10,000 psi higher strength with correspondingly less ductility as compared with annealing at 1500 F. Section sizes smaller than about ⅝ in. should be furnace cooled to 1100 F after annealing at temperatures above 1300 F to insure stability against age hardening if the alloy is to be used at elevated temperatures. Recommended anneal for sheet is 1450 F for 2 hr followed by furnace cooling to 1100 F and subsequent air cooling.

Fatigue tests conducted at 8000 rpm on Krouse rotating beam machines indicate a typical endurance limit of 80,000 psi for 10^8 cycles on annealed unnotched specimens. On notched specimens (K_t=4.5) endurance limit is 37,500 psi. Fig 1

shows fatigue curves obtained on 5/8 in. diameter bars in various heat-treat conditions. For heat treated specimens ranging from 145,000 to 200,000 psi tensile strength, ratio of unnotched endurance limit to tensile strength is 50% ± 5%.

V-notch Charpy impact strength of bar or plate of 1 in. section size or smaller averages 23 ft-lb at room temperature and 18 ft-lb at —40 F, which is considerably better than most commercial alpha-beta titanium alloys. Static notch tensile tests show no hydrogen embrittlement up to 240 parts per million hydrogen. Tests are conducted by static loading notched tensile specimens at room temperature for 5 hr at the approximate yield strength and then increasing stress at 10,000 psi increments and holding a minimum of 5 hr at each stress level, until failure occurs. The notch has a 60 deg angle with a 0.005 in. radius. The cross-sectional area under the notch is one half the original area.

Elevated temperature properties

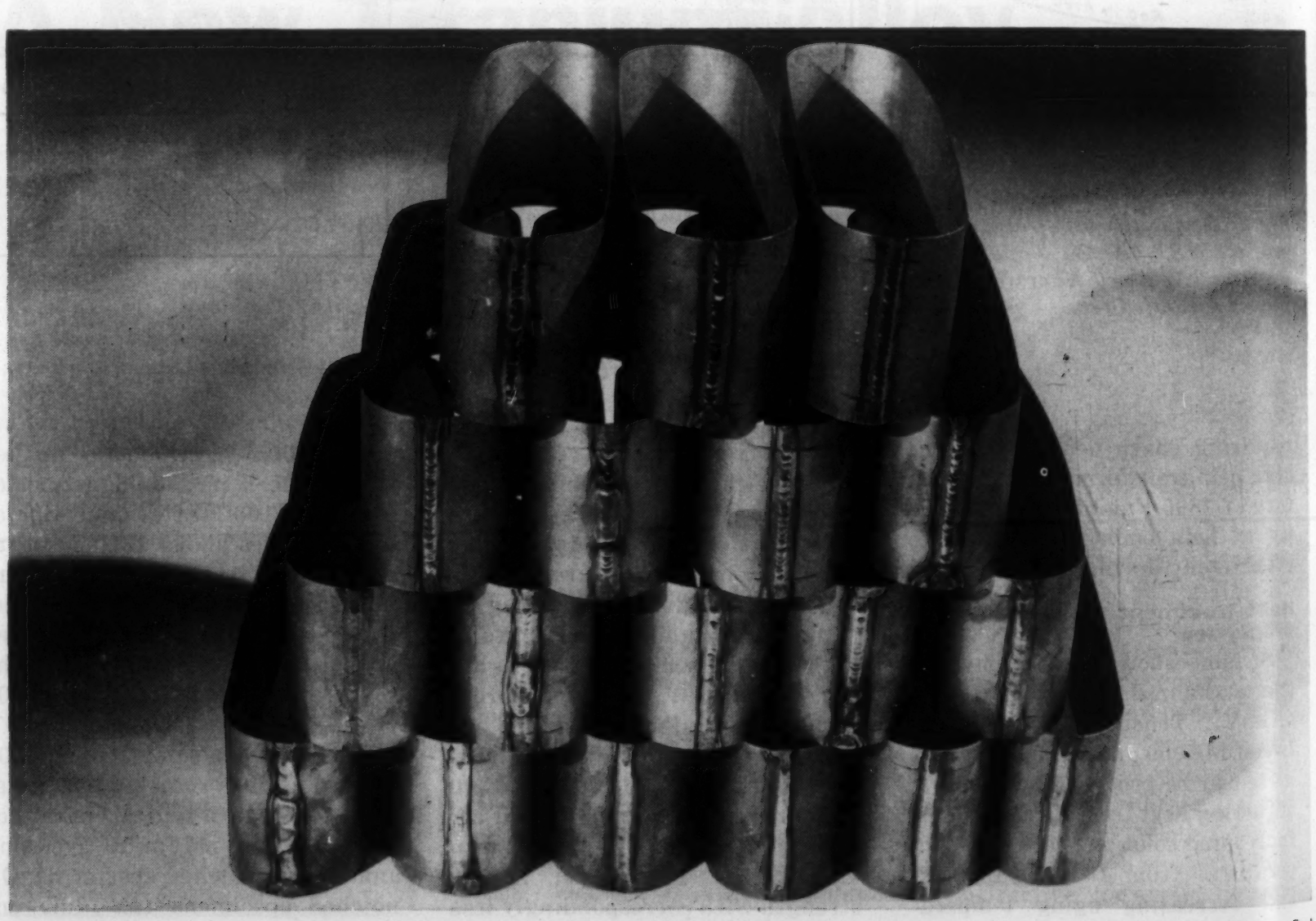
MST 6Al-4V retains usable strength up to 1000 F. Typical short-time tensile properties of annealed bar at 1000 F are 92,000 psi ultimate tensile strength, 77,000 psi 0.2% yield strength, 20% elongation and 64% reduction in area. This yield strength is at least 30,000 psi higher than that of annealed Ti-3Al-5Cr, Ti-4Al-4Mn, or Ti-5Al-2.5Sn at 1000 F. Variation of tensile properties with temperature is shown in Fig 2.

Annealed bar exhibits less than 0.2% total creep after 300 hr at 650 F and 50,000 psi stress, with no loss of ductility as evidenced by subsequent tensile testing at room temperature. Safe operating limit for the alloy ranges from about 60,000 psi stress at 700 F to 15,000 psi stress at 1000 F. Fig 3 shows creep characteristics in the annealed condition, and also effect of heat treatment on creep characteristics.

Weldability

Watertown Arsenal Lab reports that weldability of the alloy is excellent compared to that of any other alpha-beta titanium alloy. Their work on arc-welded plate using consumable, unalloyed titanium filler and a protective argon shield indicates that welds in MST 6Al-4V actually have a higher tolerance for interstitials than similar arc-welds in unalloyed commercial titanium. Also, both longitudinal and transverse tensile tests on arc welds in plate showed acceptable strength and ductility.

Preliminary results of a welding study on MST 6Al-4V sheet being conducted at Battelle Memorial Institute indicate usable ductility of welds for many applications. These welds were made with a tungsten arc torch without filler and a protective argon shield. In addition, spot welds in sheet showed good tension-shear ratios and insensitivity to hydrogen embrittlement even at 500 parts per million hydrogen.

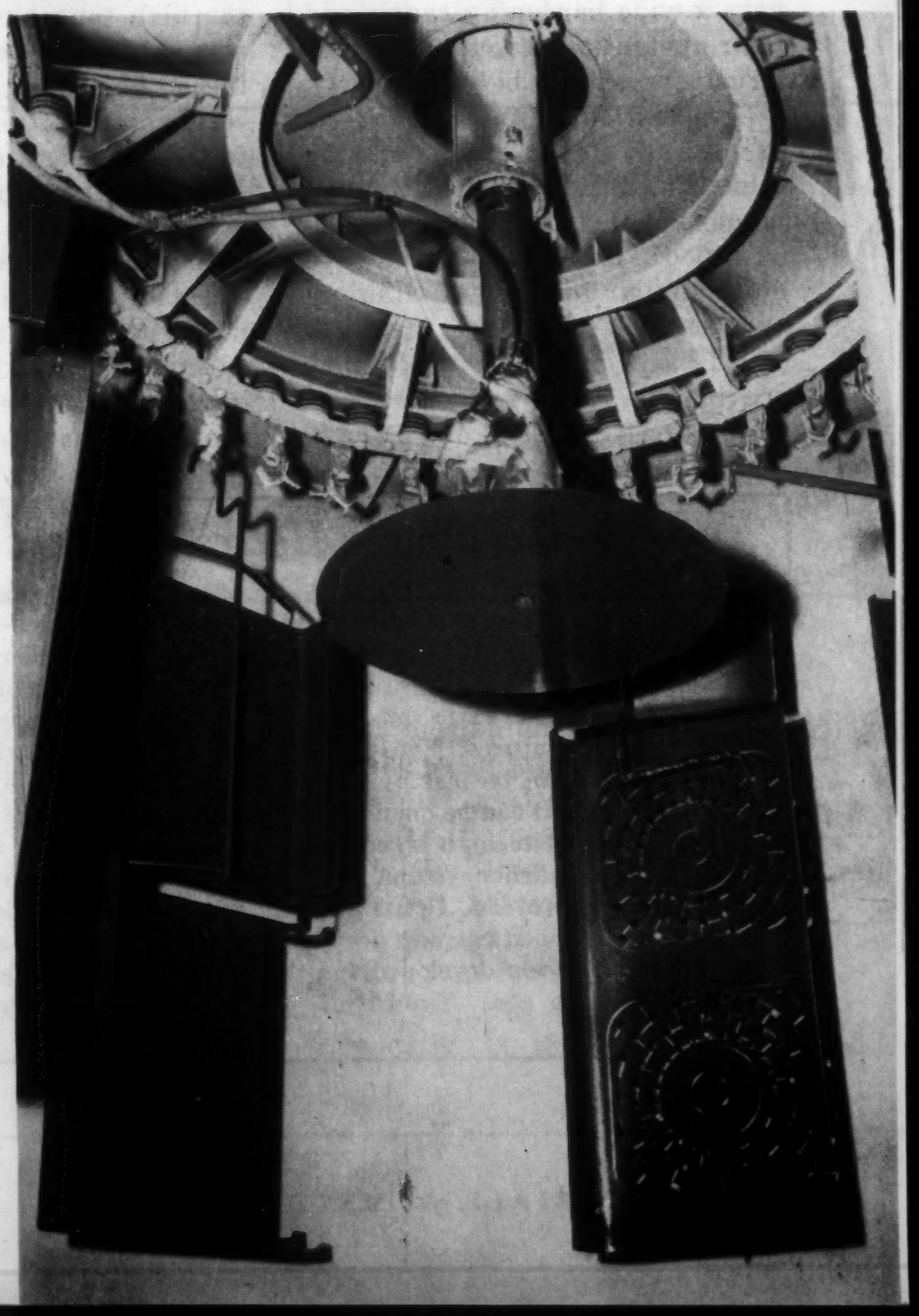


Weldability *of new alloy and high beta transus make sheet fabrication practical.* *(The Glenn L. Martin Co.)*

Silicon is Heart of Solar Battery Silicon disks which transform sunlight into electricity form the heart of this solar battery, developed by Bell Telephone Labs. This model contains 432 disks, arranged in 48 units of 9 disks each. Solar batteries will receive their first practical test this summer when an experimental unit, essentially the same as the model shown, will be installed to supply power to terminal equipment on rural telephone lines. During daylight hours the solar battery will power terminal equipment directly and, at the same time, will charge a storage battery to provide power for night operation and periods of lower sun intensity.

Electrostatic Spraying Speeds Painting Paint coverage has been more than doubled and production speeded by use of electrostatic paint spray techniques at Atlanta Stove Works, Inc. Lawn furniture to be painted is hung on conveyor attachments and passed through two paint stations to coat both sides. Ransburg disk atomizers are mounted in the center of the two loops made by the conveyor. Paint is pumped to the center of the rotating disk. High d.c. voltage, imposed on the disk, establishes an electrostatic field between the disk and the grounded parts hanging on the conveyor. This field atomizes the coating material into a fine spray which is attracted to the surrounding parts, eliminating overspray and reducing the amount of paint required.

(Additional Materials at Work on p. 106)



These Hot Work Die Steels look promising for Aircraft Structures

STEEL	PROPRIETARY GRADE	C	Mn	Si	Ni	Cr	V	W	Mo
A	Halcomb 218	0.38	0.34	1.10	0.15	5.21	0.40	—	1.38
B	Chro-Mow	0.32	0.44	0.95	0.12	5.00	0.18	1.31	1.36
C	Halcomb 1370	0.43	0.38	0.32	0.10	2.20	0.63	1.00	0.71
D	Peerless J	0.53	0.32	0.21	0.11	1.37	1.33	2.79	1.55

Here are four steels, two of them already well known in the tool and die industry, that may solve some high-temperature problems in high-speed aircraft.

by Edward A. Loria, *Staff Metallurgist, Crucible Steel Co. of America*

■ For many years hot work die steels have been used successfully for tools requiring high toughness and strength at elevated temperatures. A number of these steels have a wide hardening range, and their potentialities for aircraft structures should be explored.

Compositions of four such steels are given in an accompanying table. These steels merit attention because of their low thermal coefficients of expansion which are quite similar to those of titanium and ferritic stainless. Steels A and B are chromium types that are tougher than ordinary chromium steels. Steels C and D have a resistance to softening equivalent to that of 9-12% tungsten hot work steels. Steel D, a newly developed material, also has a lower hardening temperature than the high tungsten steels. Since C and D undergo secondary hardening on tempering, they are highly resistant to softening when subjected to elevated temperature service in the quenched and tempered condition.

In selecting a superior steel for elevated temperature applications, it is necessary to evaluate the effect of elevated temperatures on mechanical properties both for short-time and for extended exposure. In some cases, the effect of extended exposure at elevated temperature upon mechanical properties at room temperature must also be considered.

Short-time properties

Significance of long-time creep and stress rupture properties in aircraft structures has not yet been fully evaluated. In many applications these properties are not critical because the parts are designed to withstand high emergency loads that will be applied for only a short time, and the steady loads are below those that would produce appreciable creep. Many aircraft parts are designed on the basis of peak load, and the most commonly determined properties are the short-time tensile properties.

The excellent strength and ductility of A and B steels at temperatures as high as 1100 F are shown in Table 1 which also gives properties of 4340. Mechanical properties at elevated temperatures depend somewhat on room-temperature properties, and maximum room-temperature properties attainable may depend considerably on the size of part heat treated, particularly in the case of 4340. Hence, it is important to note that the properties for steels A and B were obtained for 4-in. sections, air cooled and tempered, whereas the properties for 4340 were obtained on ¼-in. rounds, oil quenched and tempered.

Steels for Hotter Aircraft

As operating temperatures continue to rise, aircraft structures increasingly require materials that maintain a high strength-weight ratio at elevated temperatures. These requirements can be met by certain steels that can be quenched and tempered to high strength levels. An earlier article by Nehrenberg (M&M, Oct. 1954, p. 100) described two new deep-hardening steels developed for large landing gear. Typical of other forgings that could utilize the elevated-temperature strength retention of certain steels are the landing gear support and the engine mounting frame. Steel rod, wire, tube and sheet (protected by an aluminum coating) could also be used effectively. This article suggests consideration of a group of steels not previously evaluated for aircraft structures—steels originally developed for the tool and die industry.

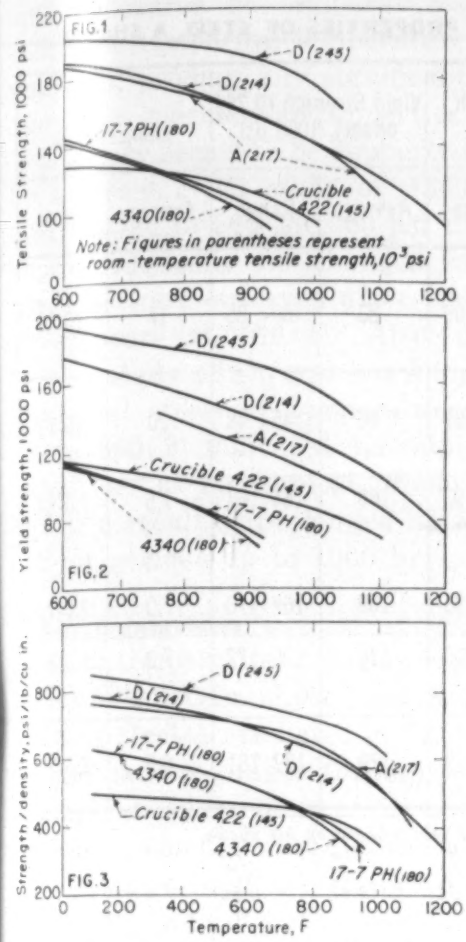


Fig 1, 2 and 3 *How short-time tensile strength, yield strength and strength-density ratio of several steels vary with temperature.*

Table 2 gives elevated-temperature tensile properties of steel D subjected to various hardening and tempering treatments. Highest tensile and yield strengths are generally obtained with the 2100 F austenitizing treatment, even with a 6-hr temper at 1225 F, but higher elongation and reduction of area are obtained with the lower austenitizing temperature of 1950 F. One heat treatment (listed second in the table) provides a tensile strength as high as 187,000 psi at 1000 F.

Let us compare steel D with Inconel X at 1000 F. When D is austenitized at 2100 F and tempered 4 hr at 1225 F to a hardness of Rc 49, it has a stress to rupture in 100 hr at 1000 F of 110,000 psi—equivalent to that of Inconel X. But this same steel D has a tensile strength at 1000 F of 183,000 psi compared to 145,000 psi for Inconel X.

In Figures 1, 2 and 3, the tensile strengths, yield strengths and strength-weight ratios of steels A and D are compared with those of other materials over the temperature range from 600 to 1200 F. These curves give two types of information. The relative positions of the curves at or about a given temperature show which materials offer superior properties for short-time exposure at that temperature. In addition, the relative slopes of the curves show which materials are structurally most stable; curves which fall away rapidly as temperature increases generally indicate materials relatively unstable at the higher temperatures, e.g., 17-7 PH and the martensitic steels.

Effect of alloy content can be seen by comparing ultimate strengths of steels A and D in Fig 1. The added tungsten and molybdenum in D give it better short-time heat resistance, especially beyond 1100 F. The higher carbon content of D compared to the other steels makes it possible to reach much higher strengths.

Tensile yield strengths are not used as often as ultimate strengths for design purposes. When the yield is less than two-thirds of the ultimate, however, the yield may be the limiting factor in design, since an aircraft structure is often required not to deform permanently at the highest ex-

TABLE 1—ELEVATED TEMPERATURE TENSILE PROPERTIES OF STEELS A AND B

Steel	Heat Treatment	Test Temp, F	Ten Str, psi	Yld Str (0.2 % offset), %	Elong, %	Red in Area, %
A	Air cooled from 1800 F, tempered 3 hr at 1100 F to R_C 44	80	217,000	184,000	13	40
		800	171,000	137,000	17	56
		900	155,000	125,000	20	65
		1000	145,000	105,000	19	65
		1100	110,000	88,000	21	69
B	Air cooled from 1800 F, tempered 3 hr at 1100 F to R_C 44	80	205,000	185,000	12	42
		800	182,000	152,000	18	49
		900	167,000	147,000	19	55
		1000	137,000	120,000	25	64
		1100	121,000	103,000	18	72
4340	Oil quenched from 1550 F, tempered 2 hr at 850 F to R_C 43	80	198,000	188,000	14	53
		600	177,000	146,000	21	65
		700	164,000	138,000	20	71
		800	142,000	126,000	22	68
	Oil quenched from 1550 F, tempered 2 hr at 1170 F to R_C 32	80	143,000	129,000	20	62
		500	140,000	107,000	21	53
		700	122,000	96,000	25	72
		850	103,000	86,000	26	76
		1000	80,000	58,000	34	87

TABLE 2—ELEVATED TEMPERATURE TENSILE PROPERTIES OF STEEL D

Heat Treatment	Test Temp, F	Ten Str, psi	Yld Str (0.2 % offset), psi	Elong, %	Red in Area, %
Oil quenched from 1950 F, tempered 3 hr at 1250 F to R_C 46	80	214,000	204,000	10	30
	800	173,000	153,000	11	40
	1000	142,000	126,000	14	48
	1200	93,000	72,000	13	28
Oil quenched from 1950 F, tempered 2 hr at 1150 F to R_C 52	80	256,000	232,000	8	25
	1000	187,000	162,000	13	39
Oil quenched from 2100 F, tempered 6 hr at 1225 F to R_C 49	80	245,000	227,000	7	21
	800	198,000	178,000	10	34
	900	193,000	174,000	8	29
	1000	176,000	158,000	7	19
Oil quenched from 2100 F, tempered 4 hr at 1225 F to R_C 51	80	259,000	243,000	6	19
	800	209,000	188,000	7	27
Annealed at 1600 F, tempered 16 hr at 1400 F to R_C 10	80	88,000	60,000	29	56

pected service stress. Yield strength may also be used as an indication of proportional limit in designs where elastic properties are important. Fig 2 shows that the yield strengths of the die steels are superior to those of 4340 and 17-7 PH over the entire elevated temperature range. Note the stability of 422 in the 600-800 F range. Although yield strengths of steel A are lower than those of steel D throughout this temperature range, yield strengths of steel B (not shown on chart) are equivalent to those of D up to 800 F. As the chart indicates, yield strength of D above 1000 F is outstanding.

Fig 3 shows the marked superiority of the die steels in strength-weight ratio over the entire temperature range. Highest ratios are obtained for steel D that was austenitized at 2150 F. Ratios for D austenitized at 1950 F overlap the ratios for A at temperatures up to 1000 F, above which D shows superiority. Ratios for 4340 and 17-7 PH overlap in the 200-800 F range and are higher than those for 422. However, 422 is stable in this range and has higher ratios than 4340 and 17-7 PH above 800 F.

Long-time properties

The elevated-temperature tensile data given above are based on short exposure times. Within a certain temperature range these properties are maintained during long exposures, but at higher temperatures these properties decrease as a function of time. Both effects are "structure-sensitive phenomena", characteristic of each individual steel.

One way to estimate the temperature ranges in which the desired properties will remain relatively constant for a certain time is by means of master tempering curves. Such curves show the combined effect of temperature and exposure time on hardness. Actual use of master tempering curves is explained elsewhere in this article.

Fig 4 gives master tempering curves for the four die steels. Note the flatness of the curve for D which shows only a three-point drop in hardness over the extremely wide parameter range of 28,000 to 35,000. In the 1150-1350 F range, steel D is more temper-resistant than commercial 18-4-1 high speed steel. Specifically, two hour cumulative tempering treatments at 1200 to 1350 F drop hardness from 56 to 42 Rc for steel D compared to 52 to 38 Rc for 18-4-1. Steel D is much superior to steel A in resistance to tempering, and C has intermediate temper resistance.

Let us compare these die steels with 4340. The master tempering curve (not show on chart) shows that 4340 heat treated to Rc 43 loses hardness rapidly when subjected to temperatures over 850 F. A 2-hr exposure at 1000 F may drop its hardness to Rc 35 or lower. Steels A and B heat treated to Rc 44, however, can be exposed to 1000 F for as long as 10 hr without losing any hardness and will have a hardness of Rc 40 or higher even after a 100-hr exposure.

It has long been felt that long-

TABLE 3—ROOM TEMPERATURE TENSILE PROPERTIES OF STEEL A SHEET[a]

Heat Treatment	Heat[b]	Tensile Strength, 1000 psi		Yield Strength (0.2% offset), 1000 psi		Elongation, %	
		Average	Range	Average	Range	Average	Range
Annealed at 1430 F, cooled 10 F per hr to R_B 95	H	108	106–109	83	80– 86	17	16–19
Annealed at 1550 F, cooled 10 F per hr to R_B 85	T	89	85– 91	46	45– 48	20	16–23
Annealed as shown above. Salt quenched from 1800 F, air cooled from 1000 F, double tempered 4 hr at 1125 F to R_C 42–44	H	192	191–193	166	164–167	7.5	7.0–8.0
	T	193	192–195	169	167–170	7.0	7.0–7.5
Annealed as shown above. Salt quenched from 1800 F, air cooled from 1000 F, double tempered 4 hr at 1100 F to R_C 42–46	H	204	203–205	176	175–178	7.0	6.0–8.0
	T	209	207–212	179	177–181	6.5	6.0–7.0

[a] *Hot rolled, annealed and pickled, 0.040 x 36 x 72 in. All values based on five sheets.*
[b] *Composition:*

	C	Mn	Si	Cr	Mo	V
Heat H	0.38	0.41	1.05	5.01	1.33	0.33
Heat T	0.34	0.34	1.00	5.02	1.37	0.32

TABLE 4—TOUGHNESS AT ELEVATED TEMPERATURES

Steel	Heat Treatment	Hardness, Rc	Charpy V-notch Impact Value, ft lb					
			80 F	200 F	300 F	500 F	800 F	1000 F
A	Air cooled from 1800 F, tempered 5 hr at 1100 F	45	24	30	31	41	38	39
B	Air cooled from 1800 F, tempered 4 hr at 1100 F	44	18	26	30	37	40	44
C	Air cooled from 1900 F, tempered 2 hr at 1200 F	45	11	15	20	21	—	—
D	Oil quenched from 1950 F, tempered 3 hr at 1250 F	46	9	12	—	—	10	10

time exposures at temperatures under the tempering temperature would not produce any significant change in mechanical properties. This theory seems to be supported by a recent NBS study of 4340 heat treated to 260-280,000 psi in which practically no changes in hardness were observed after 200 hr exposure at 400 F. Also, a British study of several low alloy structural steels at temperatures up to 660 F indicated no additional loss of mechanical properties as a result of prolonged heating for periods up to 1000 hr.

Other properties

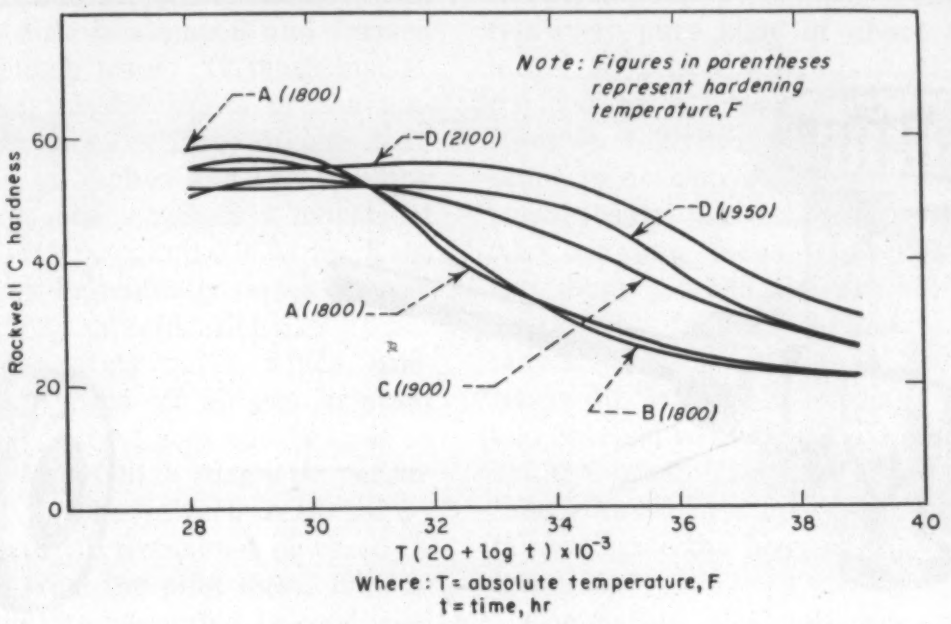
Room-temperature tensile properties of 0.040-in. sheet from two heats of steel A are listed in Table 3. The narrow ranges throughout indicate a high degree of uniformity among the different sheets tested, and the results obtained for two different hardening and tempering treatments indicate good reproducibility between heats despite normal variations in composition.

Mill-annealed properties indicate that forming of these sheets would not be a problem. Note that a hardness as low as RB 95 can be obtained with a 1420-1440 F subcritical anneal. The softer sheet can be bent 180 deg without microscopic cracking. Springback from a 90-deg bend is 12 deg for the RB 95 sheet and 8 deg for the RB 85 sheet; this difference would be important in setting up forming dies for uniform production.

Similarly, the as-annealed properties of steel D (Table 2) indicate that wire drawing would not be a problem. The excellent yield and ultimate strengths of D at elevated temperatures would make it a good choice for coiled helical springs that must be highly stressed and must operate at elevated temperatures with little or no set.

The air-quenchability of these die steels would be an important advantage in some applications. For example, much of the projected airframe sandwich structure for high speed flight requires that the sandwich be heat treated after brazing. Air quenching would greatly reduce warpage in sheet and strip.

The impact test has been generally accepted as an indicator of toughness for aircraft materials. Just how impact test results can be interpreted in terms of aircraft design has not been solved, because true impact loads of the type produced in this test are not encountered in service. However, in certain parts of the engine the stresses produced on sudden acceleration approximate impact loading. The V-notch Charpy values given in Table 4, when compared with those for materials now used in aircraft structures, show that the die steels have adequate toughness at both room and elevated temperatures.



How to Use Master Tempering Curve

Given: Steel A, tempered to Rc 45
To find: Hardness of steel A after being subjected to service temperature of 1000 F for 200 hr.

First determine what length of time at the proposed service temperature would have been required to obtain the present or starting temper. From the chart, parameter for steel A at Rc 45 is about 31,900. Thus,

$$31{,}900 = T\ (20+\log t) = 1460\ (20+\log t)$$
$$\log t = 31{,}900/1460 - 20 \cong 1.85$$
$$t \cong 70 \text{ hr}$$

In other words, steel A at Rc 45 has had a tempering treatment *equivalent* to about 70 hr at 1000 F. To find its hardness after 200 hr service at 1000 F (or a total equivalent exposure of 270 hr at 1000 F):

$$T\ (20 + \log t) = 1460\ (20 + \log 270 \cong 1460 \times 22.432$$
$$\cong 32{,}700$$

From the chart, parameter of 32,700 for steel A represents a hardness of about Rc 40.

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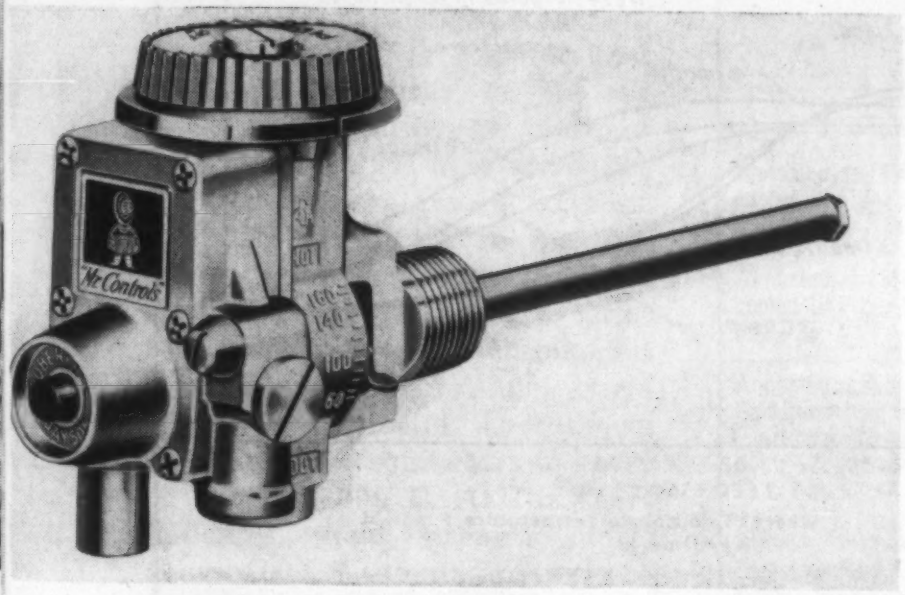
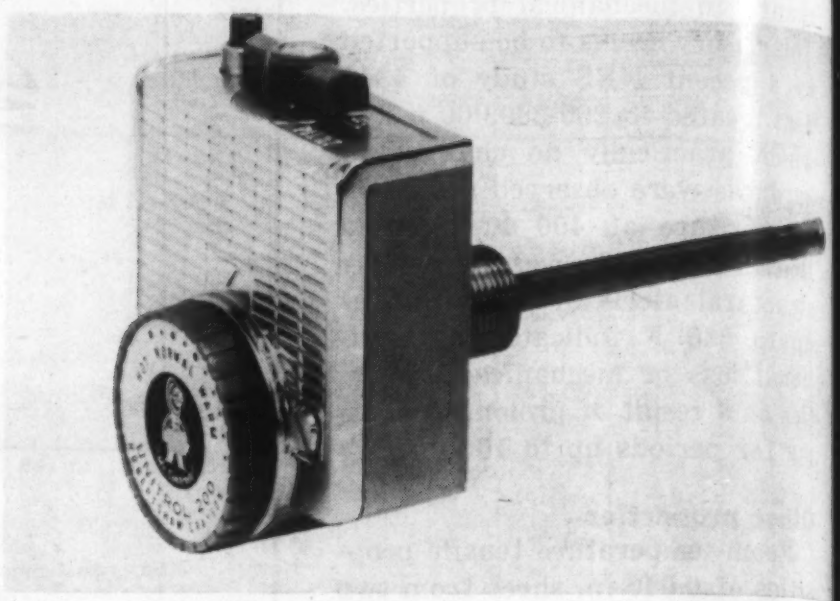




Before and after redesign. *Unit at right shows how proper materials selection and redesigning improves the appearance of water heater control.*

Corrosion Resistance . . .
Durability . . .
Attractive Appearance . . .
Economy . . .
are factors considered in . . .

Selecting Materials for Heater Control

by M. J. Caparone, *Grayson Controls Div., Robertshaw-Fulton Controls Co.*

■ Selection of metals, metal forms and plastics in a new automatic control for water heaters is based primarily on the following factors: 1) improved corrosion resistance of parts operating in "sour" gas atmospheres; 2) improved strength and durability of parts to increase accurate operating life of unit; 3) optimum freedom of design in order to produce a compact, attractive unit; and 4) improvement in manufacturing economy in order to provide the customer with the most for his money. Robertshaw-Fulton's new Unitrol 200 is representative of careful study and selection of proper engineering materials.

Aluminum

The body of the control unit (3) is an aluminum die casting. Aluminum was selected because of its resistance to corrosive effects of gases and its light weight. Changing from sand to die casting reduced machining time and permitted openings in the housing to be cast-in rather than drilled as was previously necessary. The gas cock plug (4) which permits manual operation of the unit, is die cast in aluminum because it, too, is exposed to sour gases. In many localities natural gases burned in water heaters contain traces of sulfur. Since parts are exposed to these gases for long periods of time, even a slight sulfuric content can cause corrosion if metals susceptible to corrosion are used.

Other aluminum parts include the pilot filter (8) which contains mineral wool to screen and filter gas going to the pilot light, and a snap-on aluminum cover (9) which presents a glossy, attractive appearance.

Nickel, copper and brass

Attached to the back of the control body and immersed in water during operation is the thermal unit, a 6-in. tube (2). It consists of an Invar rod housed in a pencil-sized copper tube. Invar, a 32 nickel, 68% iron alloy with a very low coefficient of thermal expansion, long ago replaced porcelain enamel or carbon rods which were too brittle and bulky for this use. Copper is quite sensitive to temperature change and when the temperature of the

water surrounding the tube drops as much as 10 degrees, the tube contracts sufficiently to push the Invar rod against a valve mechanism which opens the flow of gas to the burner, thus reheating the water. The copper tubing and the red brass (85% copper) fitting (5) which screws into the water tank will withstand indefinite exposure to hot water.

Stainless steel, magnet and plastics

The main gas flow valve is actuated indirectly by the Invar rod. As the copper tube contracts, the Invar rod pushes against a plunger which snaps a small steel disk called a clicker (6). As the clicker buckles, it opens the valve to start the flow of gas.

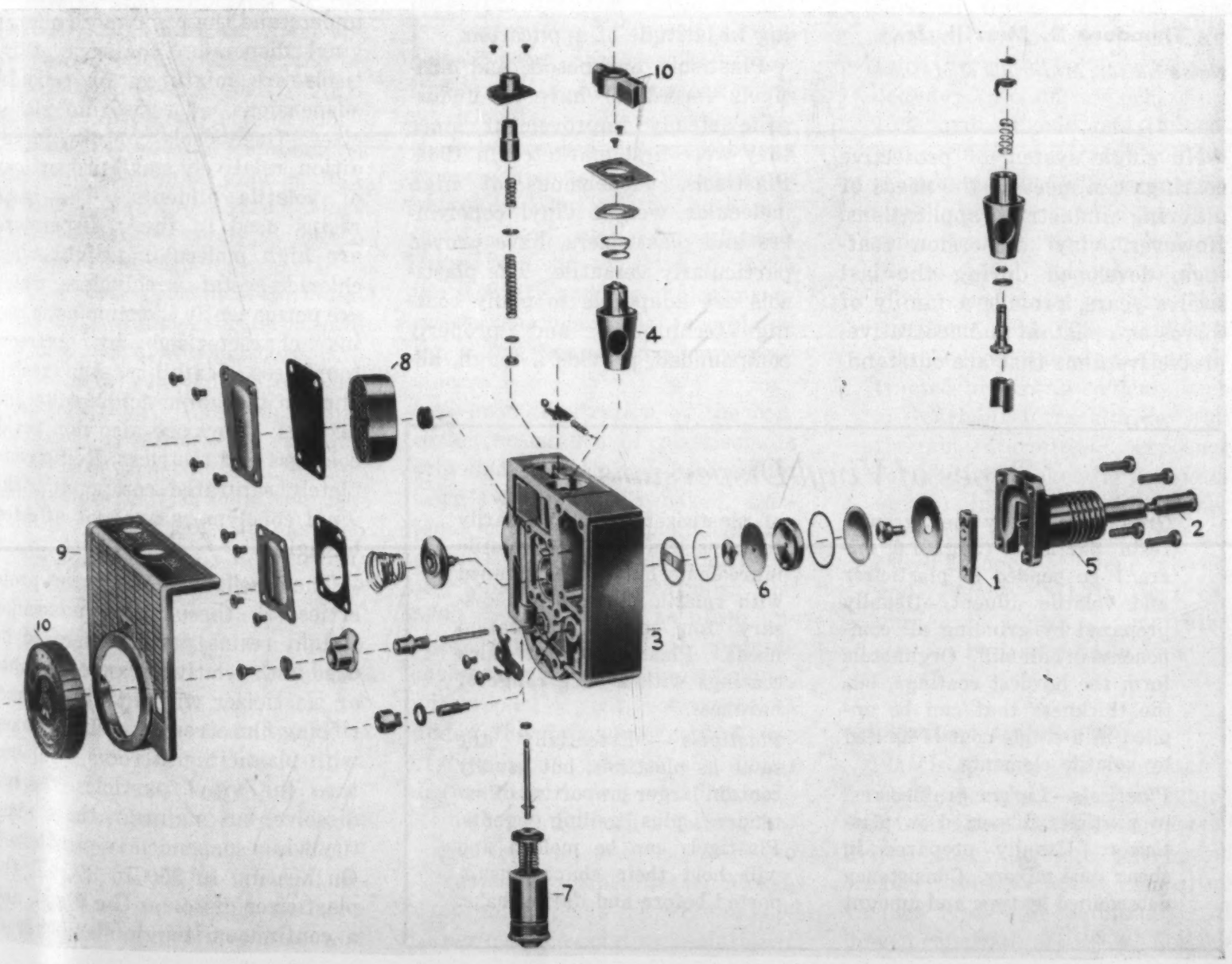
The disk is made of a 300-series stainless steel with a yield strength of 200,000 psi. Though the disk will buckle from 10,000 to 20,000 times during its normal operating life, it is designed to withstand 100,000 buckling cycles. The disk is stamped and formed by punch press. It must buckle, within elastic limits of the material, when a force of less than 50 lb is applied and the buckling action must produce a movement within 0.0002 and 0.0004 in. Each disk is individually tested to meet minimum specifications.

The safety valve which completely shuts off all gas in event the pilot light goes out depends on an alloy of high magnetic permeability. The valve is actuated by a small electromagnet powered by heat from the pilot light. The 20 milliwatts generated is conducted from the thermocouple to the magnet by copper line, holding the armature to the magnet and thus holding the gas valve open. When the pilot flame is extinguished the electromagnet is no longer energized and the armature is released, closing the gas flow valve.

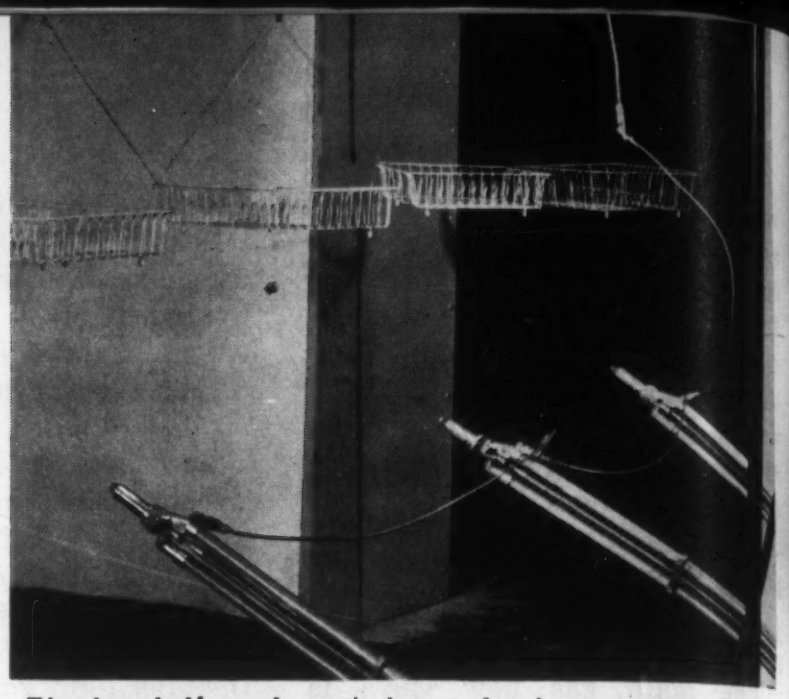
The magnet (7) is made from a relatively pure alloy of about 50 nickel, 50% iron, which is further purified by a special heat treatment and hydrogen process in order to develop a high magnetic permeability. Since there must be zero air gap between armature and magnet when the magnet is energized, facing surfaces of magnet and armature are flattened to within ±0.000001 in. and checked with an optical measuring device. The safety unit is then encased in a dust-proof container inside the body of the control unit.

Completing the unit are two plastics parts (10) both injection molded of high strength polystyrene. One is the temperature dial, the other the pointer on top of the unit. They are economical to produce, strong, and add to the attractiveness of the unit.

Numbers indicate *critical parts discussed in text.*



Sprayable platisol *deposits up to 25 mil coating in one pass. Plating tank was given an 80 mil coat in four applications.* *(United Chromium Corp.)*



Electrostatic set up *is latest development in applying sprayable plastisols. Low-waste system deposits an even, 4 mil coat on all sides of wire.* *(Scientific Electric)*

Plastisols Suited for Many Coating Jobs

As vinyl plastisol dispersion coatings grow more versatile, they fulfill a wider range of protective coating requirements.

by Theodore B. Merrill, Jr.,
News Editor, Materials & Methods

■ No single system of protective coatings can meet all the needs of differing industrial applications. However, vinyl dispersion coatings, developed during the last twelve years, provide a family of corrosion resistant and decorative-protective films that are outstanding in latitude of application.

Plastisols, organosols, and plastigels (see box) have all undergone steady improvement since they were first marketed in 1944. Plastisols, suspensions of high molecular weight vinyl copolymers and plasticizers, have proved particularly versatile. The plastisols are adaptable to many coating techniques, and properly compounded, provide a tough, adherent, hard wearing elastomeric skin that is highly resistant to weathering, acids, alkalies, detergents, and salt solutions in a temperature range from far below freezing to 200 F.

To compare the plastisols with other coating materials, and in order to choose the most satisfactory plastisol formulation from the many available, it is helpful to understand the basic mechanics of vinyl dispersion coatings. Plastisols are mixtures, or colloidal suspensions, of resin and plasticizer. Organosols contain, in addition, relatively small proportions of volatile diluents. The basic resins used in these dispersions are high molecular weight vinyl chloride-acetate copolymers, which are permanently thermoplastic resins characterized by extreme toughness, flexibility, and resistance to inorganic acids, salts and alkalies. They are also non toxic, colorless and tasteless. Being completely saturated compounds, the vinyl copolymers are not affected by aging.

The excellent film forming properties of these high molecular weight resins permit them to be used with relatively large amounts of plasticizer without unduly sacrificing film strength. When mixed with plasticizer at room temperature the vinyl particles do not dissolve, but maintain their identity while suspended in plasticizer. On heating to 350 to 375 F, the plasticizer dissolves the vinyl, and a continuous, tough elastomer is

Types of Vinyl Dispersions

Organosols—Very finely ground resin particles (avg. 1.0 micron) suspended in plasticizer and volatile diluent. Usually prepared by grinding all components in ball mill. Organosols form the hardest coatings, but the thickness that can be applied in a single coat is limited by volatile elements.

Plastisols—Larger grained resin particles dispersed in plasticizer. Usually prepared in shear type mixers. Consistency determined by type and amount of plasticizer used. Ordinarily contains less than 5% volatile ingredients but can be thinned with volatile diluents if necessary for special application needs. Plastisols form thick coatings with a wide range of hardness.

Plastigels — Essentially the same as plastisols, but usually contain larger proportion of extenders plus gelling agents. Plastigels can be molded and will hold their shape unsupported before and during bake.

Screens *for electroplating tank, hot dipped to give thick, corrosion resistant coating which provides mechanical protection.* *(United Chromium Corp.)*

Cold-dipped canvas gloves *are vapor tight, will withstand hard wear in presence of acids, alkalies or plating solutions. Gloves are reversible, fit either hand.* *(Bakelite Co.)*

formed. Plastisols, because they are suspensions rather than solutions, exhibit a wide range of flow properties, permitting the use of a variety of application techniques.

The number of specific plastisol formulations is theoretically infinite. A change in proportion or type of any of the components will affect the properties of the plastisol both before and after application. Components that can be varied include the basic vinyl resins, a wide variety of plasticizers, heat and light stabilizers, pigments, and fillers. Volatile diluents may also be added. Since plastisols are relatively simple to prepare, requiring only a stir-in type of mixer for most formulations or a simple three-roll mill for fine preparations, there is a particularly wide choice of plastisols available. While flexibility makes it possible to virtually tailor-make a coating for a specific application, and extends the usefulness of plastisols, it has also resulted in lack of standardization, which makes selection more difficult for industrial users.

Obviously, small amounts of specially prepared plastisols are more costly than standard, stocked mixes made up in production quantity by formulators. However, for large production runs, the possibility of using a specially tailor-made plastisol should not be overlooked, as it might offer considerable savings in labor cost, product performance, and production scheduling. Most formulators have facilities for such special compounding service.

Application considerations

Plastisols always require a full temperature bake to attain optimum physical properties. A longer bake at a lower temperature will not suffice, as the temperature, not the time, is the prime requisite for fusing the dispersed resin particles and plasticizer in a homogeneous film. Some low-temperature fusing plastisols are used in applications where a high temperature bake is impossible due to the base material, but such formulations should not be expected to have the stability and mechanical properties that plastisols formulated for a full temperature cure provide.

A good illustration of the corrosion resistance of plastisols is provided by United Chromium Corp.'s 5300, a fully baked, elastomeric coating compounded particularly for electroplating rack and tank lining applications. The 5300 coating, which is often applied ¼ in. thick to provide cushioning from mechanical abuse, withstood 1½ year test exposures under the following partial list of conditions without significant degradation or loss of adhesion.

At 160 F, both constant immersion in and exposure to fumes of: zinc, brass, nickel, chromium, acid-copper, and copper-cyanide plating solutions; citric, lactic, benzoic and oxalic acids; saturated and dilute solutions of alum, ammonium chloride, ammonium thiocyanate, barium sulfide, copper cyanide, di-sodium phosphate, nickel acetate, sodium di chromate, zinc sulfate, and alkaline cleaners. At 120 F, both constant immersion in and exposure to fumes of: 10% ammonium hydroxide; chromic acid; ferric chloride; formaldehyde; calcium hypochlorite; 10% hydrochloric acid; hydrogen peroxide; hydrogen sulfide; nitric acid to 35% concentration; phosphoric acid to 85% concentration; sodium hydroxide to 35%; sulfuric acid to 50% concentration; and 2% sulfurous acid. The coating is attacked or the plasticizer extracted by strong solvents such as carbon tetrachloride (although intermittent exposure for plating baskets is not damaging); butyl acetate; benzine; amyl and ethyl alcohol; methyl ethyl ketone; ethylene glycol; and gasoline. It is also degraded by highly concentrated sodium hydroxide solutions.

Application techniques

Plastisols range in consistency from the doughy plastigels, which will hold their shape unsupported before cure, through pasty and creamy consistencies exhibiting various types and combinations of flow properties, to free flowing

APPROXIMATE RANGE OF PHYSICAL PROPERTIES OF PLASTISOLS AT VARIOUS RESIN-PLASTICIZER RATIOS

Plasticizer-Resin Ratio	.5 to 1	1-1	3-1
Tensile Strength, psi	4000	1700	400
Elongation (ultimate) %	200	400	475
Hardness, Durometer A	90	55	22
Viscosity*, cp	20,000	1100	120

* At formulation.

plastisols thinned with volatile diluents that extend into the range of the organosols. The viscosity and flow characteristics of plastisols permit a wide range of coating techniques to be used. Thixotropic plastisols, which are highly viscous when undisturbed but exhibit a marked decrease in viscosity when agitated, are particularly important in the application of thick coatings to non-horizontal surfaces. The thixotropic plastisol will flow on easily, then show marked resistance to sagging. Some plastisols, particularly those with high resin loading, are dilatent—the opposite of thixotropic. Dilatent plastisols will flow slowly, but their viscosity will increase sharply with an increase in pressure, resulting in shear rather than flow. Many plastisols have both dilatent and thixotropic properties—their viscosity decreases with agitation to a certain point, then builds up again. This combination of flows is particularly useful where shear type mixers are used for compounding, and a non-drip coating is desired.

Plastisol coatings may be applied by paint brush, spraying, hot and cold dipping, knifing, spreader-coating or roller coating. For adherence to metal, a primer coat is needed, and in the case of flexible elastomeric coatings with large amounts of plasticizer, a thermosetting type of primer is advisable.

Dip Coating—For coating a large number of small items such as bolt heads, or irregular objects such as work gloves, tool handles, wire goods and electroplating racks, dip coating offers a simple and effective technique. Cold dipping, using thixotropic plastisol formulations, is effective with wire goods, gloves and other such items that do not retain enough heat to permit hot dipping. Objects must be withdrawn smoothly and slowly in order to attain a sag-free, even coating. Withdrawal rates for most plastisol dips range from 3 to 6 in. per min, but formulations now under development are reported to have nearly doubled the previous maximum rate.

Hot dipping provides an excellent technique for attaining thick coatings on tool handles, electroplating racks and other heavy metal parts. The part to be coated is heated at baking temperature (350-375 F) before dipping in plastisol, and the retained heat causes the plastisol to gel around the part in a thick, viscous layer. Using hot dip techniques, it is relatively simple to attain a single-dip coating thickness of 0.2 in. or more. If a baked primer coat is used, the part can be hot dipped in plastisol as it emerges from the bake oven, eliminating a special heating step. Thick, protective coatings for copper electroplating racks applied in this manner exhibit chemical resistance to the most severe electroplating conditions and with good primers, the coating-to-metal adhesion is as high as 40 to 60 lb per linear in.

Spray coating—Plastisols for spray gun application must be thinned with volatile diluents. The viscosity of plastisols decreases rapidly with the addition of small amounts of diluent, so that the advantage of the high solids content of plastisols is retained. Spray coating is particularly adaptable to irregular surfaced assemblies too large for dip coating. It is also easily adapted to coating the inside surfaces of drums and containers. One new sprayable plastisol composition, formulated by the United Chromium Corp. will deposit a smooth, sag-free coating up to 25 mils thick in a single pass.

Brush coating—Low viscosity plastisols with some yield value and thixotropic qualities can be applied by conventional brush or paint roller techniques.

Roll and knife coating—Continuous rolls of sheet metal can be coated in knife and roll coating equipment and given an immediate continuous bake. The flexibility and elastomeric properties of plastisols permit subsequent shearing and forming operations without loss of adhesion or coating continuity. An ingenious use of roller coating with plastisols was devised to coat the heads of thumb tacks with brightly colored plastisols after the tacks had been inserted in cardboard display plaques.

Other coating techniques—Plastisol caulking compounds and sealants can be applied by conventional trowelling techniques. The low shrinkage of plastisols, due to the absence of volatile thinners, makes them particularly effective as caulking materials.

Costs

The cost of plastisols and organosols varies considerably with formulation. Filler extended plastisols with low cost resins and low priced plasticizers are quite inexpensive and often sell in the range of $4-6 per gallon. High quality, resin-plasticized vinyl dispersions specially compounded for electrical insulation use or low plasticizer migration may cost well over $1 per pound ($10 per gallon). Careful balancing of costs versus desirable properties is always a major consideration in selecting a plastisol formulation.

Acknowledgements

Bakelite Co., A Div. of Union Carbide & Carbon Corp.
B. F. Goodrich Chemical Co., Inc.
Monsanto Chemical Co.
Naugatuck Chemical, Div. of U. S. Rubber Co.
Goodyear Tire & Rubber Co.
United Chromium Corp.
Chemical Products Corp.

Ring gears *being hardened two at a time on an oxy-gas machine. Automatic operation with electronic control holds surface temperature within 10 F of the desired temperature and hardens gears in less than half a minute.* *(Cincinnati Milling Machine Co.)*

Which Method for High Speed Surface Hardening?

Induction heating and direct gas heating both have certain advantages and limitations to be considered when selecting the method most suitable for your application.

by **W. S. Hyler and H. J. Grover,** *Battelle Memorial Institute*

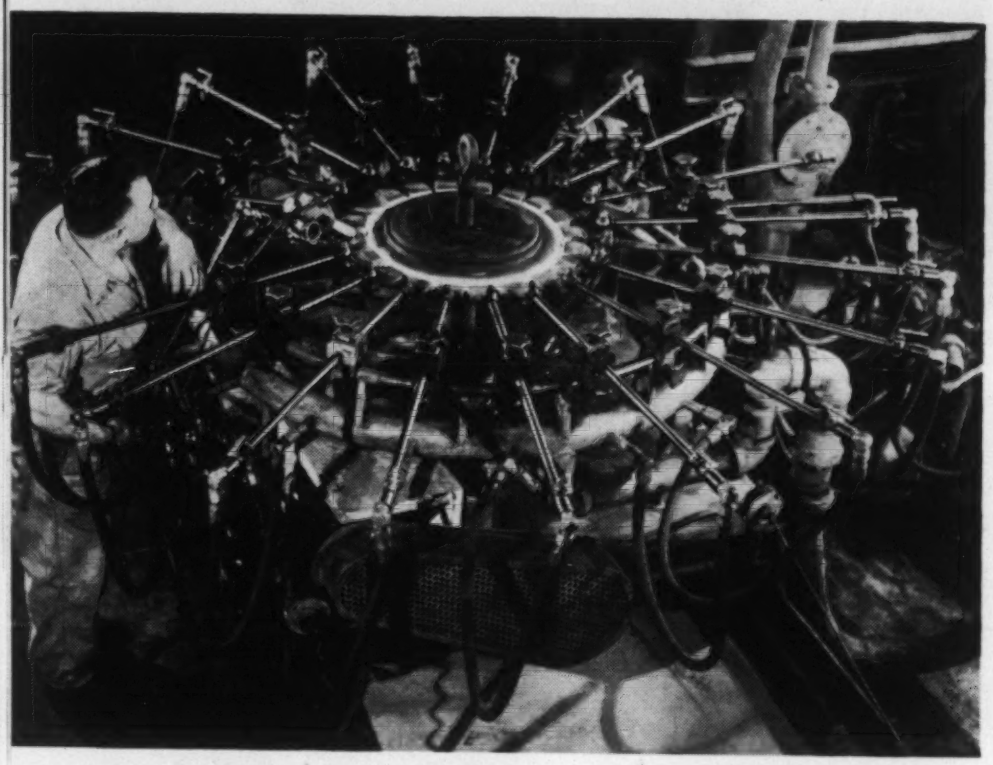
■ The highly competitive nature of the machine-tool, automotive and other fabrication industries requires continued search for methods of decreasing production costs. In recent years, it has become evident that surface hardening by high speed heating is more economical under certain conditions than conventional through-hardening or carburizing.

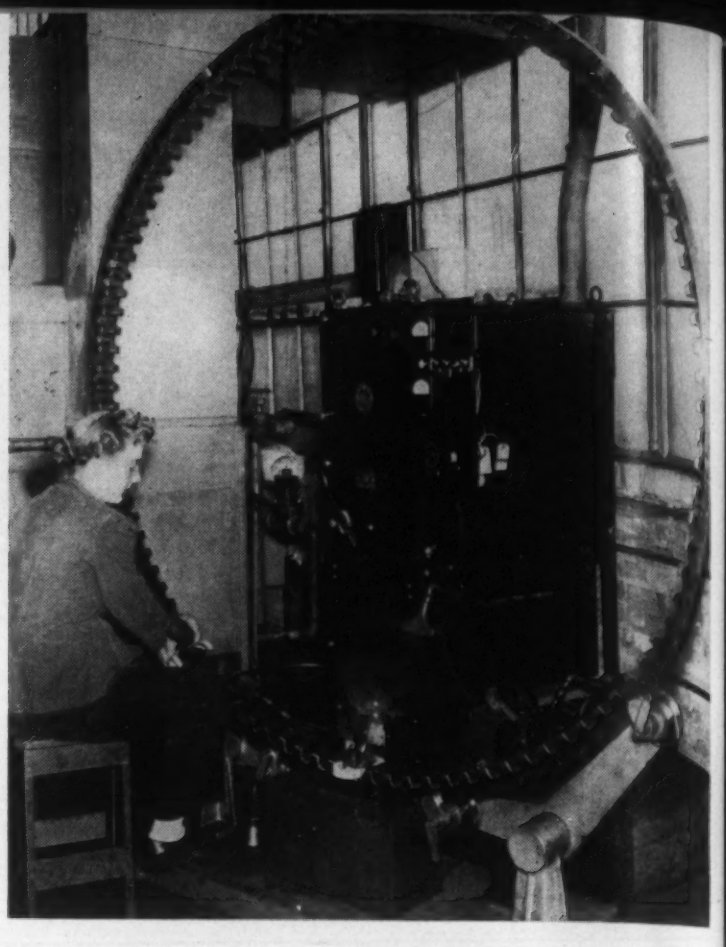
Two methods of heating are widely used for such hardening: induction heating and high speed direct gas heating. Each has certain advantages and limitations. For example, induction heating is capable of producing the shallowest case. However, except for very-thin-walled parts, where the only possibility is induction heating, the flame-hardening processes produce about the same results as induction heating does.

In most instances, the selection of the particular process to be used can be based chiefly on economic considerations. Factors of importance are: installed cost, thermal-energy costs, labor costs, and flexibility. Of these factors, energy and labor costs will be particularly dependent upon the location of the unit in the United States.

The basic requirement of all surface-hardening methods is generally the same. That is, the rate of heat input by conduction, convection, and radiation to the sur-

Gears, segments and cylinders *up to 36 in. in diameter are surface hardened with this arrangement of Selas ceramic burners at Wiedemann Machine Co. Temperature-control system alerts operator when surface of rotating workpiece reaches pre-determined temperature. Quench tanks located below unit minimize transfer time.*





Large internal gears *surface hardened by induction at Northern Pump Co. This 82-in. ring gear is hardened one tooth at a time, the 103 teeth requiring less than 18 min.* *(Ohio Crankshaft Co.)*

face, must be greater than the rate of heat transfer from the surface to the interior of the part. This results in a thermal gradient from the surface; the steeper the gradient, the more shallow is the depth of the hardened zone. The essential differences in the metallurgical quality of the hardened surfaces are a reflection of the rate of heat input to the surface.

Methods

Induction-heating — Hardening by induction heating involves the generation of heat under the surface of the steel. The rate of heat input is extremely high, actually being dependent upon the capacity of the induction unit, and is controlled by two factors: current density and current frequency.

These same factors also control the depth of hardening. For example, as the current density increases, the heat input increases and the thermal gradient also increases. Since the part to be hardened is heated to some relatively fixed surface temperature, the steep thermal gradient implies that depth of material heated into the critical temperature range is more shallow the higher the current density.

An increase in current frequency for a given current density results in a decrease in depth of hardening. Typical values are shown in a table. These minimum-depth-of-hardening values can be obtained with a high value of current density (power requirements greater than 50 kw per sq in.). If lower power requirements than 50 kw per sq in. are employed, greater case depths are obtained for the same range in current frequencies listed in the tabulation.

Ceramic-burners — Use of natural or manufactured gas for surface hardening was not successful with metallic burners. Rate of heat input was not high enough to offset heat flow from the surface inward and to build up the necessary high surface temperature to cause hardening. Ceramic burners, however, provide a small burning chamber in which complete combustion of the gas occurs. These incandescent gases are discharged from the burner at a velocity up to 1400 ft/sec and impinge upon the surface of the part. In addition to heat input by conduction and convection, these burners are so designed as to be efficient sources of radiant energy. Thus, sufficient heat input is provided at the surface to set up the high surface temperatures and high thermal gradients needed for hardening.

Although these ceramic burners successfully harden steel parts, the rate of heat input is less than that attainable with induction heating. Thus, the minimum depth of hardened case obtained with ceramic burner installations is about 0.125 in. while that for induction heating (9600 cps) is about 0.040 in.

Conventional oxy-gas burners— Machines of this type, which employ oxy-acetylene as the heating medium, have a higher rate of heat input than ceramic burner installations since combustion of oxyacetylene mixtures occurs at temperatures near 6000 F. It is therefore possible to harden thinner layers with this equipment than with ceramic burner installations, the minimum depth being about 0.060 in.

These machines can be made fully automatic by incorporating a radiation device which measures the surface temperature of the

piece being hardened. When a predetermined surface temperature is reached, the work-holding device is retracted, flow of gas is shut off, and the work piece enters the quenching medium on a conveyor. Since the machine only uses oxygen and gas during the heating cycle this phase of its operation is similar to induction heating equipment, which uses electrical energy only during heating.

Methods evaluated

Many articles have appeared in which the performance of steel parts hardened by various rapid-heating techniques is discussed. In general, few of the articles provide information for a fair appraisal of the merits of the competing processes, because they usually report results obtained by only one method.

The American Gas Association sponsored a research program at Battelle Memorial Institute to establish information for judging the merits of induction heating and high-speed gas heating. This investigation indicated that:

1. An increase of case depth up to 0.225 in. did not cause detectable distortion of heat-treated parts.

2. Provided the case depth were the same, mechanical tests (for example, fatigue tests) did not show quality differences between specimens surface hardened by induction heating and those by flame heating.

3. No particular merit appeared to be associated with a very-shallow-hardened zone. For case depths less than 0.130 in., case hardness showed wide scatter, as indicated by Knoop hardness studies. This might be attributed to observed free ferrite in the surface zone of shallow-hardened parts.

4. Producing deep cases by gas heating generally resulted in coarser-grained structures than those observed using induction heating. Grain size had no significant effect on the mechanical properties of the case.

5. Gears hardened by the two methods of surface heating and tested under simulated-service conditions had essentially the same surface fatigue characteristics.

6. The choice between induction hardening and flame hardening can be made chiefly on economic considerations.

RELATION BETWEEN FREQUENCY AND DEPTH OF HARDENING BY INDUCTION

Current Frequency, cycles/sec	Minimum Depth of Hardened Zone, in.
3000	0.060
9600	0.040
120,000	0.030
500,000	0.020
1,000,000	0.010

Economic considerations

The four major economic factors to consider in weighing the choice between induction-hardening and flame-hardening processes are: 1) equipment costs, 2) thermal-energy costs, 3) labor costs, and 4) flexibility.

For units having the same output, a Battelle survey showed that a gas-heating unit has an installation cost ranging from 50-80% of that for an induction-heating unit. The spread in cost of gas-heating equipment depends upon the degree of mechanization required. Thus, a hardening machine equipped with oxy-gas burners of capacity equivalent to the induction-heating unit is on the high side of this range. However, the operation of the machine is as fully automatic as that of the induction-heating equipment.

Based on unit cost of thermal energy the processes can be rated in the following order of increasing cost; ceramic-burner (air-gas) installations, oxy-gas installations, and induction-hardening equipment. As a rough approximation, for equal cost, the ratio of Btu supplied by the combustion of natural gas to that supplied in the form of electrical energy for induction heating is about 6:1. It should be pointed out that the greater unit cost of electrical energy is somewhat compensated by the difference in operation of the two units. For example, in ceramic-burner installations, gas is burned during the entire period in which the machine is in operation while in induction hardening, electrical energy is used only while the part is being heated. This is true also of oxy-gas machines.

Since induction-heating equipment and Flamatic (oxy-gas) machines are fully automatic and gas-hardening units are more frequently semiautomatic, greater skill will probably be required to operate the latter equipment. Thus labor costs for air-gas hardening may be somewhat higher than they are for induction-heating and oxy-gas heating machines.

A number of factors must be considered from the standpoint of flexibility. Maximum efficiency of an inductor coil results when the coil is slightly larger than the work piece. This means that a large supply of inductor coils must be kept on hand if the unit is to be used to harden a variety of parts. These coils usually have a long useful life, and initial cost of a representative inventory of inductor coils may be offset by low-replacement cost.

Ceramic-burner installations and oxy-gas machines do not require the precise spacing of burners that is necessary for induction heating. This suggests that these installations may have somewhat greater flexibility than the induction-heating unit. Burner-replacement costs, however, partially offset this advantage.

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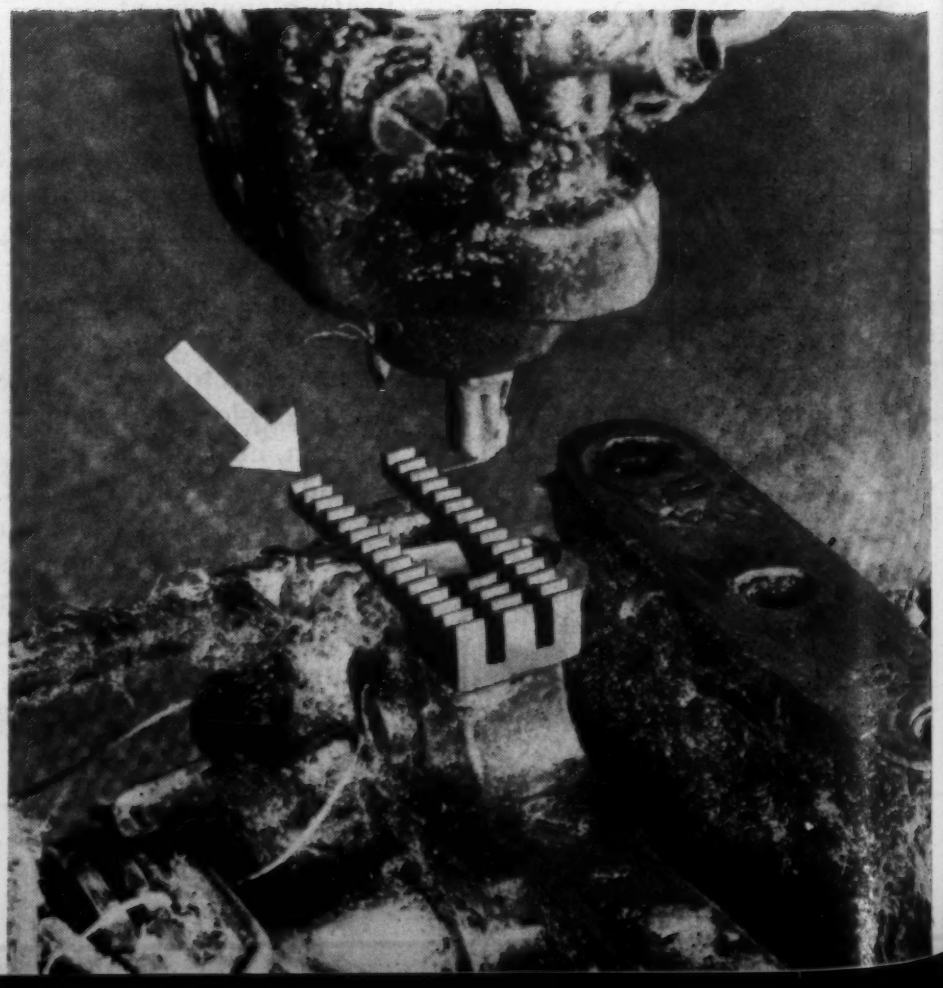
Enameled Steel Forms World's Largest Globe

Measuring more than 29 ft in diameter, what is said to be the world's largest globe was recently completed by the Bettinger Corp. for the Babson Institute. Consisting of 584 separate pieces of porcelain enamel-on-steel, the globe makes use of 21 colors, each of which had to be applied and fired separately. According to Bettinger, it marks the first time any project involving use of metal formed in a compound radius has been carried out with porcelain enamel. Porcelain enamel was selected because of its permanence and resulting reduction in maintenance costs.

Flame-Plating Cuts Cost

Cost of sewing machine feed dogs is being reduced up to 70% through the use of standard steel dogs, flame-plated with a thin coat of tungsten carbide. The coating extends service life of standard steel feed dogs as much as 6 times. Cost of the plated dog is 30% that of the six dogs it replaces. Developed by Linde Air Products Co., a Div. of Union Carbide and Carbon Corp., coatings have an as-coated finish of about 125 rms, and are said to have a wear life comparable to that of solid sintered tungsten carbide while costing only 1/6 as much.

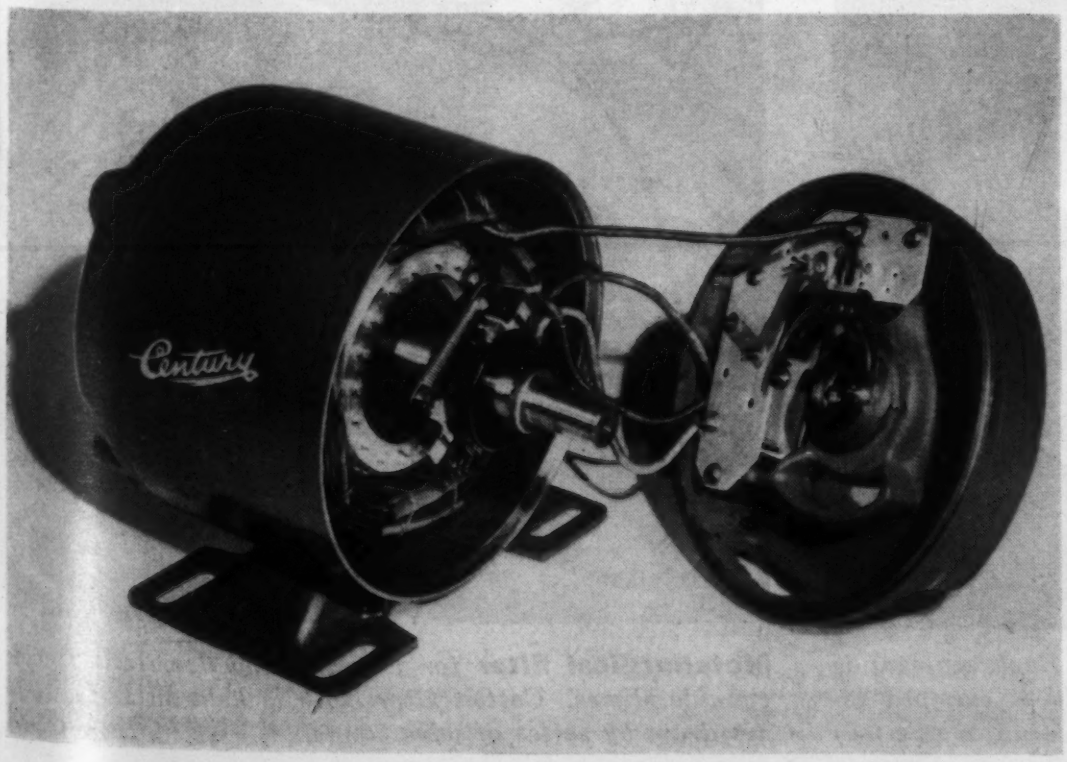


Glass, Silicone Rubber Form New Tire

Silicones and glass, derivatives of rock and sand, are the basic ingredients of an experimental tire which will withstand a temperature range of −90 to over 500 F. Developed by U. S. Rubber Co. and Dow Corning Corp., the new tires are made by coating glass fibers and standard bead wires with a silicone adhesive and using Silastic silicone rubber for ply skimcoating, treads and sidewalls. Still in developmental stages, the tire is said to be too expensive for commercial automotive use. Specialized applications are anticipated in high speed aircraft use where tires may be exposed to temperatures in the 400-500 F range.

Materials Change Cuts Cost of Mounting Plate

A total cost reduction of 35.5% is said to have resulted from a change from canvas-phenolic to glass-polyester laminates used for cutout switch mounting plates in small, single-phase induction motors. The saving is attributable to 1) 25% lower material cost through reduction in thickness of the plates from ⅛ to 3/32 in., and 2) 10.5% lower basic cost of the polyester laminate on a volume-corrected basis. The polyester laminate is molded to size for The Century Electric Co. by The Glastic Corp.



Additional advantages gained include greater reliability with respect to dimensional stability under changing humidity, and resistance to tracking between terminals. Changing the material also permitted Century to change from hot punching to cold punching techniques. Impact strength of MM Glastic is 15.0 vs 5.0 ft-lb per in. notch for standard CE phenolic sheet; water absorption of 0.5 vs 1.5% for phenolic; and ASTM arc resistance of 120 sec as compared to 5 sec for the phenolic.

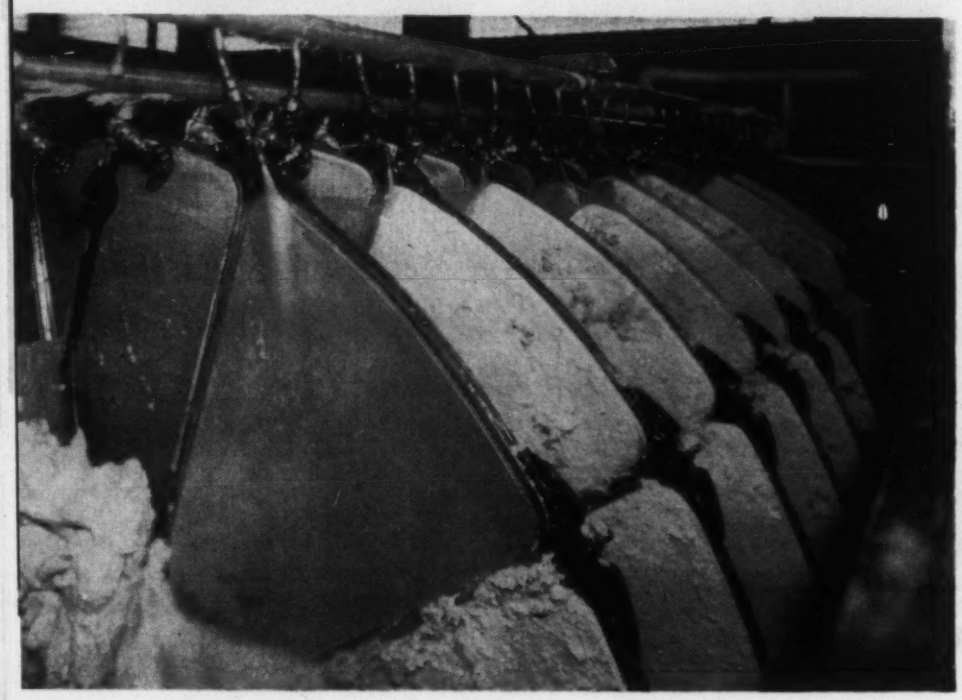
Consider the basic fibers when

Selecting Fabrics for

Fabrics are the most common industrial filtering medium. The type of fiber in the fabric has an important bearing on filter life and performance.

by Theodore B. Merrill, Jr., *News Editor, Materials & Methods*

Sluice jets *on 9-ft dia 12 disk American Saveall filter unit wash filter cake from leaves of disk. Mechanical punishment is severe.* *(Dorr Oliver)*



Cotton twill filter cloth *in place on a leaf type pressure filter. Cloth is fitted on frames as open end bag, and open seam is sewn in place.* *(Dorr Oliver)*

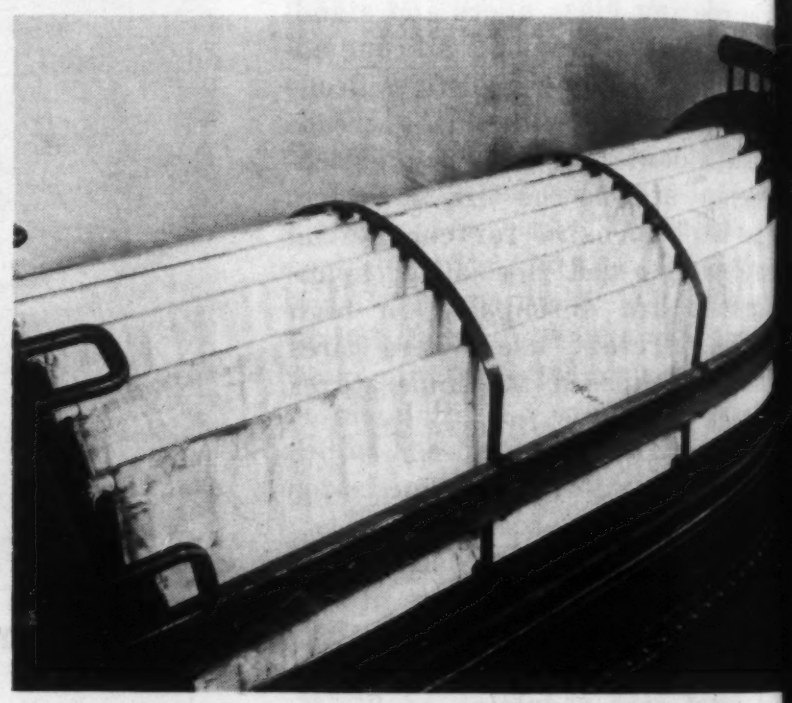
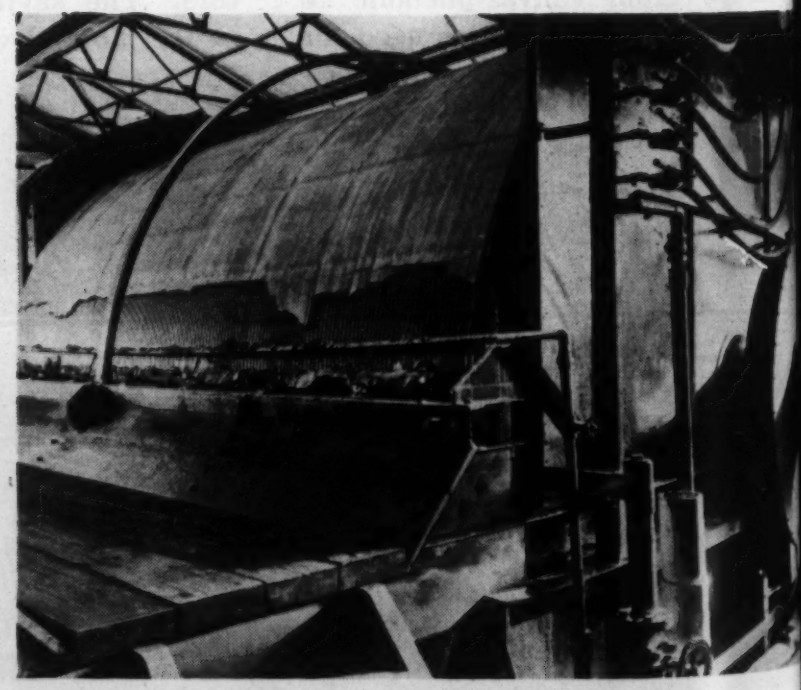


Plate and frame type *filter presses. Each segment is covered with filter cloth, then assembly is clamped together. Filter fabric acts as gasket.* *(Schriver)*



Metallurgical filter *for washing and dewatering gold-cyanide slimes. Cotton filter cloth is held on 18-ft, 14-ft dia drum by series of wire bands.* *(Dorr Oliver)*

Filtration Use

Selection of the proper filter medium is tied to the basic objective of the filter process—whether a fluid or gas is to be clarified, or a valuable solid is to be recovered. In some operations, the two processes are combined, and even a third added, such as a leaching bath.

In commercial applications, a filter medium must meet three primary considerations:

1. Efficient flow rate
2. Satisfactory quality of product (filter cake or liquid)
3. Satisfactory mechanical and chemical properties

The selection of filter media will depend upon the nature of the material to be filtered, the cake, the pressure differential, temperature, chemical conditions and type of equipment used. A densely packed cake yields a slow flow and a porous cake, faster flow. Higher pressure can increase flow rate to a point, but may result in filter cake collapse and put excessive demands on the strength of the filter medium.

Woven cloth is the most widely used filter medium, but is by no means the only material to be considered. Porous, punched, or woven-mesh metals are often used. Ceramic filters are indicated in some cases. Wool felt resists certain hot solutions, but tends to break down under scraping. Glass fiber is heat resistant, but has limitations in respect to flexing and abrasion resistance. Glass fiber also requires special gasketing compounds in plate-and-frame units. Paper and non-woven fabrics are often used in applications requiring a high degree of filtrate clarity, but generally require a fabric or screen backing for mechanical support.

Filtration methods

Pressure filtration—Plate and frame equipment used in pressure filters puts strong demands on the fabric strength, and requires good gasketing qualities of the fabric in order to seal the edges of the filter frames. While some fabrics are designed specifically to facilitate cake discharge, the filter fabric is subject to abrasion when the cake is removed from the fabric. On certain pressure plate filtration units, the fabric must be pierced to accommodate fittings. To maintain dimensional stability, preshrinking may be required for cotton, and heat setting for synthetic fabrics. If the filters are used with different filtrates, the filter media may have to have a wide range of chemical resistance.

Vacuum filtration—Vacuum filtration units are used primarily in continuous process applications, usually involving rotating-drum filters or disc-type rotating filters. Vacuum draws the liquid through the filter medium. The cake is either scraped off, or allowed to dry and then blown off, or both actions may be combined. Filter media for vacuum filtration units must resist the chemical action of the slurry; the abrasion incurred in cake removal; the mechanical stresses imposed by vacuum; and must not become clogged unduly during use.

Fabric filters

Both vacuum and pressure units generally use woven fabric filters. Cotton cloth is the most common filter fabric, since it combines good

CHEMICAL AND HEAT RESISTANCE OF FILTER FABRICS

Type of Exposure	% Conc.	Nylon		Orlon			Dynel	Teflon	Cotton
		Semi-Dull Staple	Bright Filament	Semi-Dull Staple	Bright Filament	Semi-Dull Filament	Staple	Filament	Staple
Sulfuric Acid Solution	2	72	71						
	10	52	48						Poor
	20	20	22	Avg	Avg	Avg	Avg	**	Str
	30	0	0	98	103	101	95		Retent
	40	—	—						
Nitric Acid Solution	2	58	41						
	10	18	26	Avg	Avg	Avg	Avg	**	Poor
	20	0	8	99	99	99	90		Str
	30	—	—						Retent
	40	—	—						
Sodium Hydroxide Solution	2	99		70	87	85	94		
	10	96		34	0	0	93		Good
	20	94	Avg	21	0	0	89	**	Str
	30	95	94	—	—	—	86		Retent
	40	98		—	—	—	84		
Dry Heat (in oven at 350 F)	No. of hr exposed								
	24	58	8	103*	66	65	0	**	44
	72	30	6	102*	31	34	0		0
	120	24	5	99*	22	25	0		0
Wet Heat (Saturated Steam at 15 b Pressure, 250 F)	3	65	99	101	98	97	0	**	101

Note; All figures above represent % of original fabric strength retained, and are not to be confused with fiber tests.

** Although tests indicate high strength retention, excessive shrinkage generally precludes use of this or other acrylic fabrics at this temperature level.*

*** Teflon fabrics are still in the experimental category. Teflon fibers withstand all conditions listed without deleterious effects and it was not considered necessary to put the fabric through the testing program.*

mechanical performance with low cost. The synthetic-fiber fabrics, while higher in initial cost, are becoming more important, as their higher cost is often offset by superior service qualities. The type of fiber used in the filter fabric has an important bearing upon the basic physical and chemical properties of the filter medium. The type and form of fiber, yarn, weave, thread count, and finish are all involved in determining chemical or heat resistance, durability, rate of flow, ease of cake removal, and product quality.

The strength of filter fabrics depends on both the construction and the fiber. In selecting a filter medium, the fiber—natural or synthetic—is the first consideration, and is determined by chemical, heat and mechanical service conditions.

Cotton

Raw cotton is in the form of staple fibers, which must be spun into yarn for the production of fabric. For filter use, cotton has important economic and physical advantages. It remains a low cost material despite the price fluctuations of raw material. Physically, cotton gives good service. The fibers have a natural twist, have excellent spinning qualities and form strong yarns. Cotton fabrics are durable and have excellent wet strength, two important considerations in filter service.

Synthetic fibers

Synthetic fibers are produced in two forms—staple and continuous filament. Their wide range of chemical, physical and mechanical properties, plus the "tailor made" qualities of the fiber itself, offer particular opportunities for the design and production of "engineered" filter media. Synthetic fibers have two outstanding advantages: first, uniformity is controlled; second, cost is relatively stable and subject to decline as production expands. The chief synthetic fibers used in filter cloth include: nylon, Dynel, Orlon, Teflon and glass.

Nylon—Nylon is produced in both filament and staple form. It has many physical properties significant to filtration: high tenacity, both wet and dry; outstanding abrasion and flex resistance; toughness and elasticity; resistance to heat; and mildew and bacteria resistance. A particular advantage of filament nylon filter cloth is surface slickness; i.e. the filter cake will drop away with a minimum of scraping. Nylon fabric is higher in initial cost, but offers long term advantages that warrant the added expense.

Acrylics—In general, acrylic fibers have good properties in regard to low moisture absorption, good strength, resilience, dimensional stability and chemical- and bacteria-resistance. The earilest acrylic type fiber was Union Carbide and Carbon Corp.'s Vinyon N, a copolymer of acrylonitrile and vinyl chloride. Wellington Sears pioneered the use of the filament form of this acrylic in the filter fabric field. The present version of Union Carbide's acrylic fiber in staple form is Dynel, which has high chemical resistance to both acids and alkalies and will not support combustion. Du Pont's Orlon, first of the 100% acrylic fibers, shares the qualities of Dynel, and has particularly good resistance to heat and acids. Filament Orlon, like filament nylon, yields a fabric of smooth texture and favorable cake-parting properties.

Tetrafluorethylene — Fibers of Du Pont's Teflon have exceptional heat and chemical resistance. The almost complete chemical inertness of the material and the non-adhesive, non-wetting characteristics provide long life and simplify cake removal. Heat resistance to the range of 500 F makes it a candidate for use in applications previously restricted to metal and ceramic filtration media.

Glass—Glass fibers, because of the large surface area exposed, are subject to dissolution in aqueous media. However, glass fabrics have good heat and acid resistance, a characteristic that is useful in many specialized applications. Because of a sensitivity to abrasion, glass is not well suited for applications involving scraping or excessive flexing. Glass fabric and glass mat both provide excellent service in gas filtration systems, particularly at high temperatures.

Fabric construction

A basic advantage in using fabrics for filtration is the wide range of void sizes, fiber configurations and choice of materials available. The weaves used in fabric construction are, as in all fabrics, variations of the different systems used in interlacing the lengthwise warp yarns with the crosswise filling yarns. The three basic weaves; plain, or "one up and one down"; twill, formed by passing a warp yarn over two or more filling yarns, moving one pick forward with each warp; and satin, with even fewer interlacings spaced widely but regularly, have many variations affecting filter performance. The count can be varied, producing a tighter or looser weave, with consequent increase or decrease in void size.

Two or more types of fibers can be combined in a single fabric to provide a combination of good strength and filtration characteristics. For example, a filament warp can be combined with a spun staple filling. Plied yarns, formed by twisting several yarns together, or cabled yarns, formed by twisting plied yarns together into a cable, are further variations applicable to warp and fill. Whatever the weave, type, yarn size and thread count determine the tightness of weave. A low count will leave large voids, and allow fast flow, and a high count will provide better particle retention at a slower rate.

Generally, the basic material used for the fibers will determine service life, cost, chemical and heat resistance characteristics. The durability of the fabric, and its performance as a filter, is dependent on both the fiber material and the fabric construction.

Acknowledgment

The author wishes to acknowledge the assistance of Wellington Sears Co. and West Point Manufacturing Co. in the preparation and review of this article, which was adapted from Wellington Sears' booklet "Filter Fabric Facts."

Photo credit: Heintz Manufacturing Co. (left); Lockheed Aircraft, Inc. (right).

Impact (Cold) Extruded Parts

by John L. Everhart, *Associate Editor, Materials & Methods*

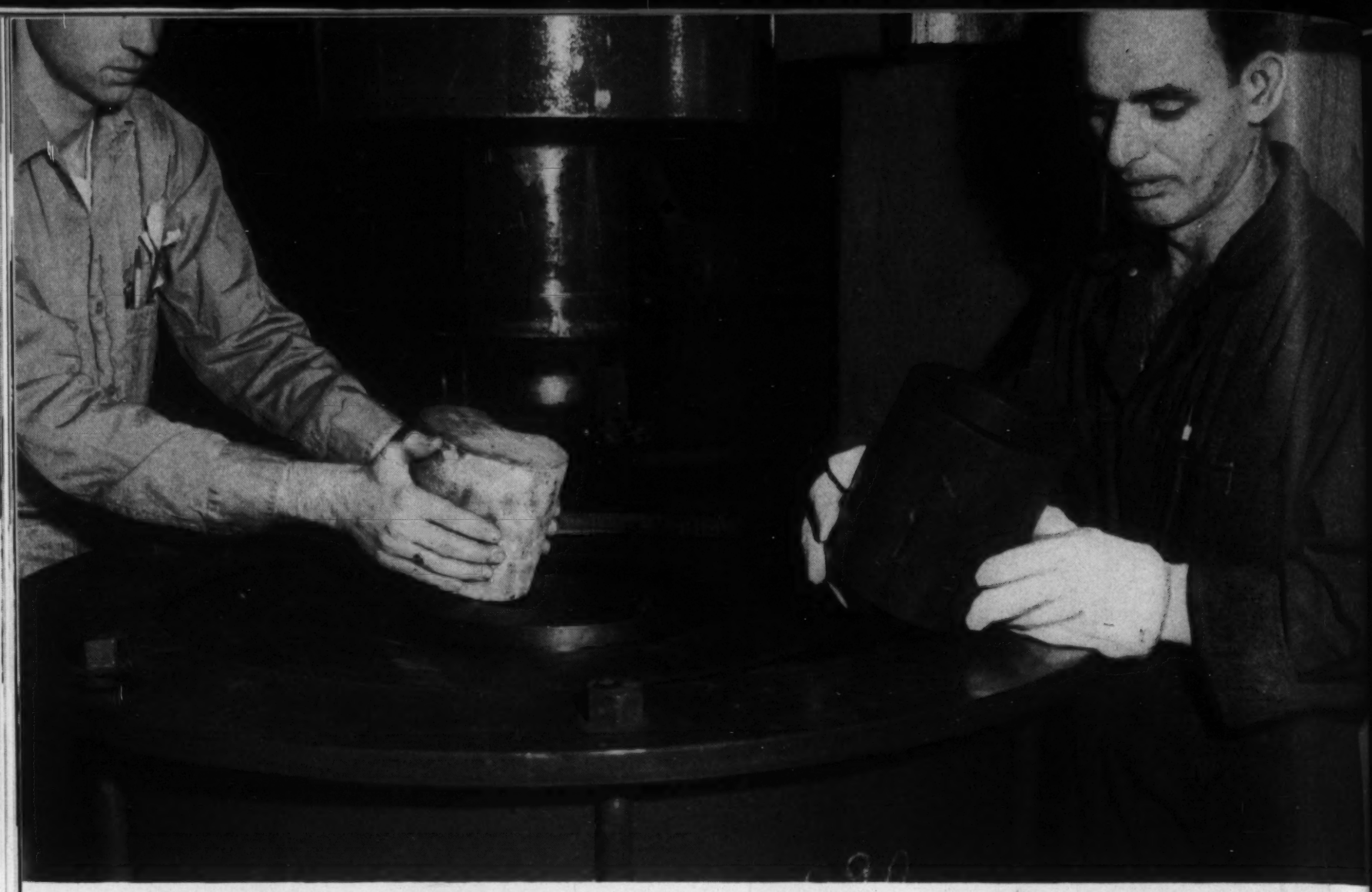
MATERIALS & METHODS MANUAL No. 118

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

AUGUST, 1955

For many years impact or cold extruded parts have been limited to collapsible tubes and simple cans. Now extended to production of a wide variety of parts, the process is finding application in many industrial fields. This Manual describes the process and discusses sizes, shapes, limitations and applications of parts produced from

- *Aluminum and Aluminum Alloys*
- *Magnesium and Magnesium Alloys*
- *Steels*
- *Other Nonferrous Metals*



Heavy backward extrusion *of a steel part at Heintz. Phosphate-coated billet being inserted into die. At the right, an operator holds the extruded part.* *(Pennsylvania Salt Manufacturing Co.)*

Advantages and Limitations

Advantages

High speed production possible.

Low unit cost of mass produced parts.

Material saving with excellent metal recovery.

Fewer operational steps.

Dimensional uniformity with close diametrical tolerances.

Tooling relatively cheap.

Surface finishes on the order of 20 to 70 microinches obtainable.

Bottom thicknesses independent of wall thicknesses.

Combines operations by forming ribs, fins, holes, etc. during extrusion.

Parts can be made with zero degree draft angles and sharp corner radii.

Excellent properties. For example, cold formed low or medium carbon steel parts have mechanical properties equivalent to heat treated carbon and low alloy steels.

Disadvantages

Relatively few alloys can be processed commercially at present.

Limitations on shapes which can be produced.

Length to diameter ratio is restricted.

Maximum size of part determined by press capacity.

Comparatively high equipment costs limit applications to relatively high production runs.

■ Impact or cold extrusions were available for many years only as collapsible tubes and other simple can shapes in lead, tin and aluminum. Continued development, particularly in the last ten years, has made it possible to produce parts from steels, strong aluminum alloys and other nonferrous metals. Such parts are now finding use in the automotive, aircraft, ordnance, appliance and electronic fields.

This Manual is intended to give the engineer and designer information on kinds of parts that can be made from various metals by this method, and to describe the process briefly with emphasis on its advantages and limitations. Much of the information was obtained from a questionnaire sent to all known producers of impact extrusions in this country and a number in England.

Why use them

Selection of impact extrusions

should be considered if 1) the bottom must be considerably thicker than the side-walls, 2) bosses or projections are needed on the bottom, 3) fluted or ribbed side-walls are incorporated in the design, 4) flanges are needed at top or bottom and 5) the length-diameter ratio exceeds 2 to 1. Some of the advantages and disadvantages of impact extrusions are given in tables. These are general properties inherent in the process itself.

In some fields impact extrusions and deep drawn parts are competitive. Where either method can be employed, an impact extrusion may be selected because it can be produced as a deep shell with fewer operations. For example, the production of a straight-sided round can 2 in. in dia and 16 in. long by deep drawing would require multi-stage operations, if it could be produced at all, while the same product could be formed in one operation by impact extrusion. Tooling for the latter process would probably be one-third as expensive as that for drawing, production rates would be higher and scrap losses lower.

Parts produced by impact extrusion are lighter and stronger than those produced by casting. Further, closer tolerances are possible, thus reducing machining costs. Greater metal yield and lower scrap losses are obtained also.

Cold extrusion yields a more concentric product than forging and produces parts more uniform in weight. The surface finish is also superior, and finishing operations can be reduced. An important advantage is the ability to obtain high mechanical properties with low carbon steel because of the drastic cold working to which the steel is subjected during the operation. This permits the substitution of a low priced steel for an alloy steel.

Briefly, these are some of the reasons for selecting impact extrusions. Others will be apparent from the discussion of the process and applications of parts produced from various materials.

Needed: A Name

The process used to produce the parts discussed in this Manual has been called by a variety of names including impact extrusion, cold extrusion, cold pressing, heavy cold forming, extrusion pressing and cold forging, to mention a few. The fact that no term has been evolved which is recognized universally indicates that the process is still in the development stage although the original application, production of collapsible tubes, is over a century old. Of the terms mentioned, impact extrusion is used most frequently by organizations producing nonferrous parts, and cold extrusion is preferred by the producers of steel parts.

There appears to be no standard American definition for the process. However, in Germany it is called Kaltspritzen by the Stamped Metal Institute and is defined as "Kaltspritzen, using a punch and die, is the process of transforming a blank in the cold state into a tubular part, during which the material is forced to flow under a high, rapidly applied pressure". The literal translation of Kaltspritzen is "cold-squirting".

In America and Great Britain the original term for the process was impact extrusion. It implied that the part was formed by forcing metal to flow through an orifice by striking it an impact blow. This term is not strictly accurate, for in many cases, at least with the softer metals, it can be demonstrated that given a press of sufficient capacity, the metal can be forced to flow through the orifice merely by squeezing. However, the term impact extrusion has merit in the fact that it has been established for a long period as a distinctive production process, readily distinguishable from normal extrusion and forging.

Cold extrusion is a term which was introduced with the application of impact extrusion to ferrous metallurgy. Although the product is an extrusion through an orifice, the advocates of the term cold extrusion state that the optimum speed is not great enough to justify calling it impact extrusion. The inventor does not agree with this thesis, for the original German patent describing the cold extrusion of steel states that "the invented process, herewith described, eliminates the undesirable features of existing cold and hot forming of hard metals by the application of the kaltspritzen process used in the manufacture of hollow, nonferrous shapes to similar shapes made of steel".

Selection of the term cold extrusion has merit, however. The process is a form of cold work, if such working is defined as that conducted below the recrystallization temperature of the metal. It should be noted that even though extrusion is started with blanks at ambient temperature, resistance to flow during extrusion is great enough to raise the temperature of the part and tools several hundred degrees. However, the temperature rise with most metals is not sufficient to reach the recrystallization temperature, and parts are produced in the work hardened condition. Exceptions are tin and lead which, of course, undergo hot working at room temperature.

Sachs has called the process under discussion, extrusion-forging. This term is probably the most descriptive of any used and might well be adopted by both ferrous and nonferrous producers. It eliminates "impact" and "cold", both of which are of doubtful validity, and it offers the possibility of a further distinction based on the kind of working involved. Thus the process could be subdivided into cold extrusion-forging and hot extrusion-forging in a manner analogous with cold rolling and hot rolling.

Regardless of what it is called, basically the same process is involved, and much greater progress in the application of this technique would be made if a single term were selected to characterize it. For the purposes of the Manual, impact extrusion and cold extrusion are used interchangeably.

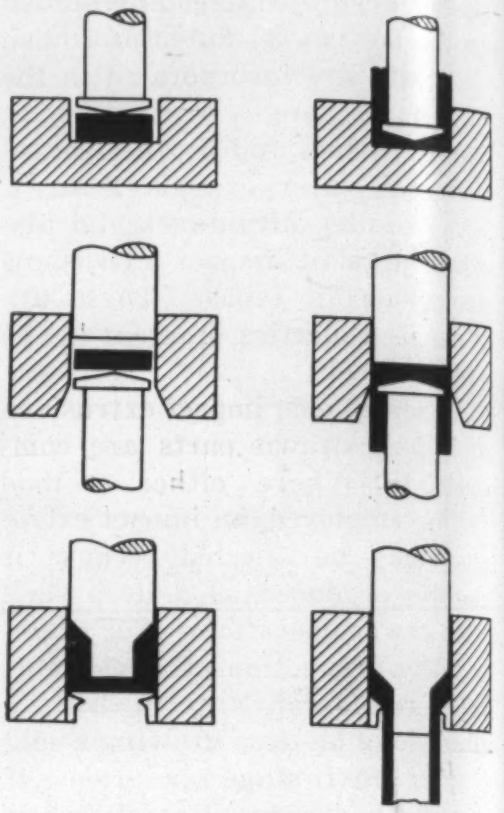
How Impact Extrusions Are Made

Two impact extrusion methods are shown schematically in an accompanying sketch. In the original method, *backward extrusion,* a blank of the material to be extruded is placed in the cavity of a die and struck with a punch moving at a high velocity. The metal in the blank is forced upward through the annular opening between punch and die and rises along the punch. The wall thickness of the part is determined by the clearance between punch and die while the thickness of the base is determined by setting the press and is independent of the wall-thickness.

In a modification of this method, the punch is fixed to the base of the press and a moving plunger which fits the die closely, strikes the blank and forces it to extrude over the punch. Certain factors will determine which of these two procedures is preferable for a given operation.

In backward extrusion, the punch must be long enough to take care of the entire length of the extruded shell plus trimming allowance. Therefore, if the original method is used, a long stroke press is frequently required. In the modified method, the punch is required only to strike a thin blank and a short-stroke press can be used.

The original method has the advantage of simplicity of tooling and ease of removal of the shell after forming. A major problem in the use of the modified method is removal of the part. Stripping the shell from the tool requires a complicated arrangement since some means of opening the die must be employed. In the original method, play in the moving head of the press increases the tendency of the punch to float and makes it more difficult to maintain uniform wall-thicknesses. The modified method has the advantage that the punch is attached to the bed of the press and can be held rigidly in the center of the die, thus minimizing the lack of symmetry in the extruded parts.



In the original method of backward extrusion, the slug is struck by the punch and the metal flows backward over the punch. In the modified method, the slug is struck by a plunger which fits tightly in the die and forces the metal over the punch. In forward extrusion, the slug is struck by the punch and flows in the same direction as the punch.

The second method is known as *forward extrusion,* generally, although the original name was Hooker extrusion. In this method, a thick blank, usually preformed to the desired contour is struck by a punch and flows forward through an orifice in the die to a considerable distance beyond the end of the punch. Forward extrusion requires less pressure than backward extrusion and smaller presses can be used for the production of parts. Unlike backward extrusion, where the walls are usually parallel, tapered sidewalls can be produced by forward extrusion.

Backward and forward extrusion can be combined to produce some rather complex parts. By machining a suitable opening in the die, metal can be forced to

Impact Extrusions vs Other Formed Parts

How does impact extrusion differ from deep drawing? Both use a combination of punch and die to form a hollow shell from a cold blank. In the production of some parts, equivalent speeds are used. The difference lies in the manner in which deformation occurs. In impact extrusion the metal is forced through an orifice between punch and die under compressive stresses while in deep drawing the metal is pulled into the die by the punch and stressed in tension.

How does impact extrusion differ from ordinary extrusion? Both involve forcing a metal through a die under compressive stresses. In this case the differences are much less distinctive since impact extrusion involves a combination of extrusion and forging. However, the metal is generally cold worked in impact extrusion and hot worked in ordinary extrusion. A further distinction lies in the type of product. The product of impact extrusion is a single component which may or may not require additional operations to produce the finished part. The product of ordinary extrusion is generally a rod, tube, structural shape or similar semi-finished mill product.

How does impact extrusion differ from forging? An impact extruded part can be considered as a modified forging in which the flash forms the sidewalls. The part has a base which, in backward extrusion at least, is a forging, and sidewalls which are extrusions.

flow sidewise also to produce flanges. Removal of such a part requires opening the die and it is more expeditious to produce flanges by extruding from the inner edge of the punch.

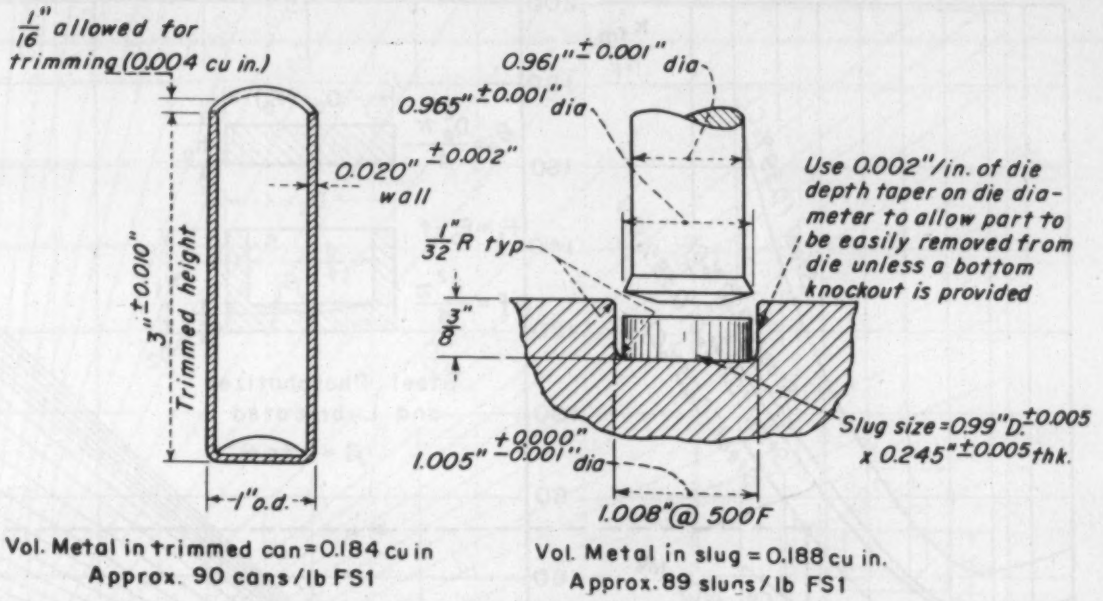
Tooling

The selection of press type is a subject of considerable debate. Mechanical presses are favored by most producers. Their reasons are based on such factors as greater speed of punch movement than hydraulic presses, high production rate, low maintenance and lower capital cost than hydraulic presses. The advocates of hydraulic presses state that they have better control of flow in relation to speed. One producer finds no difference in the parts produced regardless of whether hydraulic or mechanical presses are used.

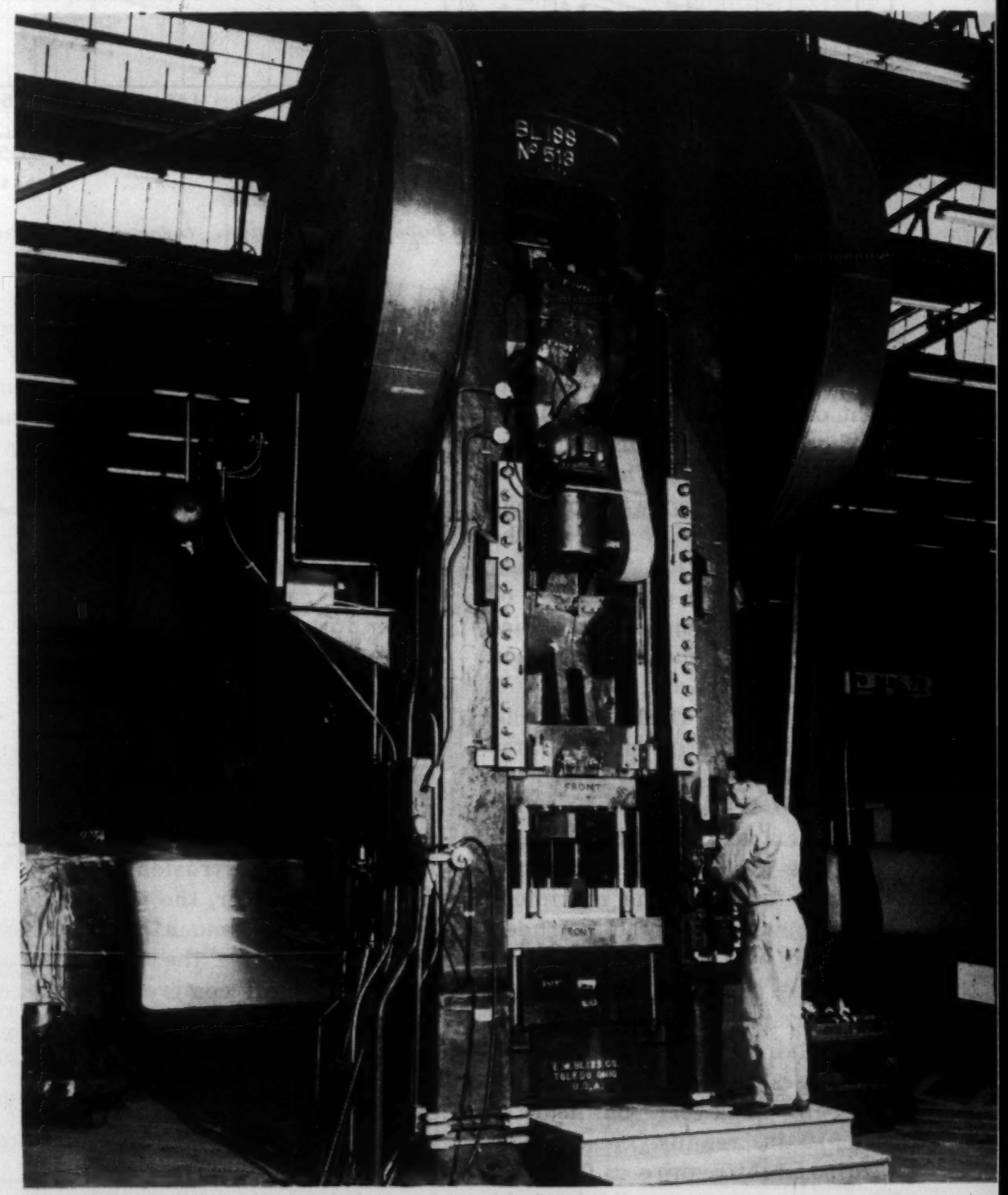
An accompanying sketch shows the form of punch and die used for the backward extrusion of a flat-bottomed can and indicates important dimensions. The punch is beveled slightly around the bottom edge to facilitate flow of the metal and this produces a slightly greater thickness at the junction of the bottom and the side-wall.

In backward extrusion, because of the length of the punch, there is a tendency for floating to occur, with a resulting variation in wall thicknesses. This tendency can be minimized by producing symmetrical parts and by proper design of the bottom contour. For flat bottom cans, a 15 deg punch bevel will help minimize floating. For irregular shapes, it is often necessary to determine proper angles by experiment. The outside corners and edge radii must also be rounded to ease the flow of metal during extrusion. These radii should be at least 1/32 in.

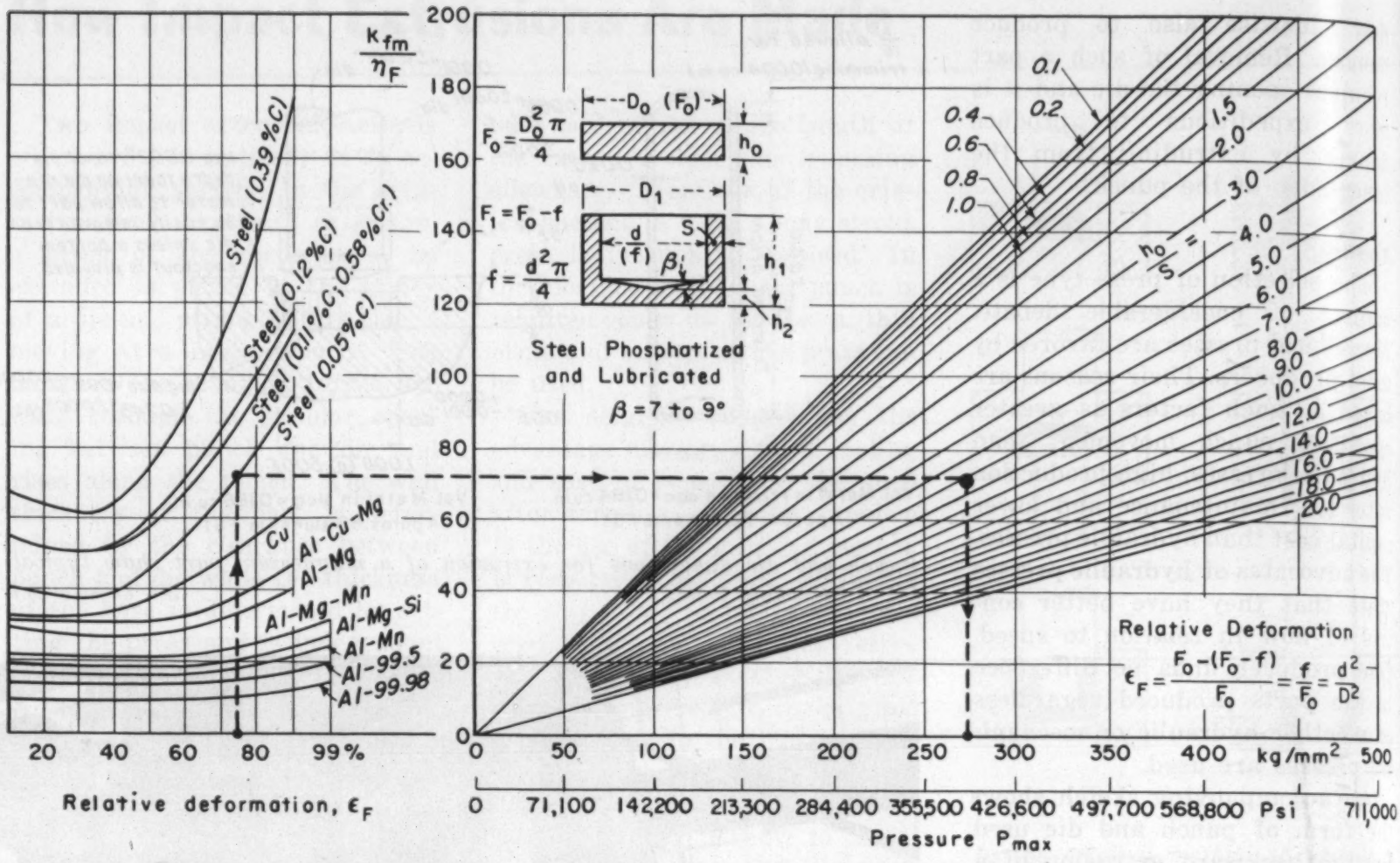
Less difficulties are experienced with the forward extrusion tools than with those designed for backward extrusion. The short, rugged construction of the punch, which can be used because punch length is practically independent of part length, reduces working problems. In addition, true alignment of


1/16" allowed for trimming (0.004 cu in.)
3" ±0.010" Trimmed height
1" o.d.
0.020" ±0.002" wall
0.961" ±0.001" dia
0.965" ±0.001" dia
1/32" R typ
3/8"
Use 0.002"/in. of die depth taper on die diameter to allow part to be easily removed from die unless a bottom knockout is provided
Slug size = 0.99" D. ±0.005 x 0.245" ±0.005 thk.
1.005" +0.000" −0.001" dia
1.008" @ 500F
Vol. Metal in trimmed can = 0.184 cu in
Approx. 90 cans/lb FS1
Vol. Metal in slug = 0.188 cu in.
Approx. 89 slugs/lb FS1

Punch and die dimensions for extrusion of a magnesium part show typical set of extrusion tools. (Dow Chemical Co.)



Nonferrous parts *are usually formed by a single stroke of the press; ferrous parts frequently require a series of operations.* (Lockheed Aircraft Corp.)



Nomograph for the pressure required in backward extrusion. (*Adapted by H. J. Pessl from* Verein Deutscher Ingenieure, *Mar. 1953.*)

punch and die are assured by the tooling arrangement.

There is considerable disagreement on the relationship between the diameter of the punch and the length of the part which can be extruded by the backward method. However, practically all of the producers agree that the limiting factor is buckling or deflection of the punch during operation. Ratios of length to diameter have been given variously as 3 to 1 for steel, and up to 10 to 1 for aluminum while one producer states that the limit is set by the press stroke and the slug volume. For forward extrusion, the limit seems to be the available clearance for the part to flow. The maximum diameter which can be extruded is limited by the capacity of the equipment.

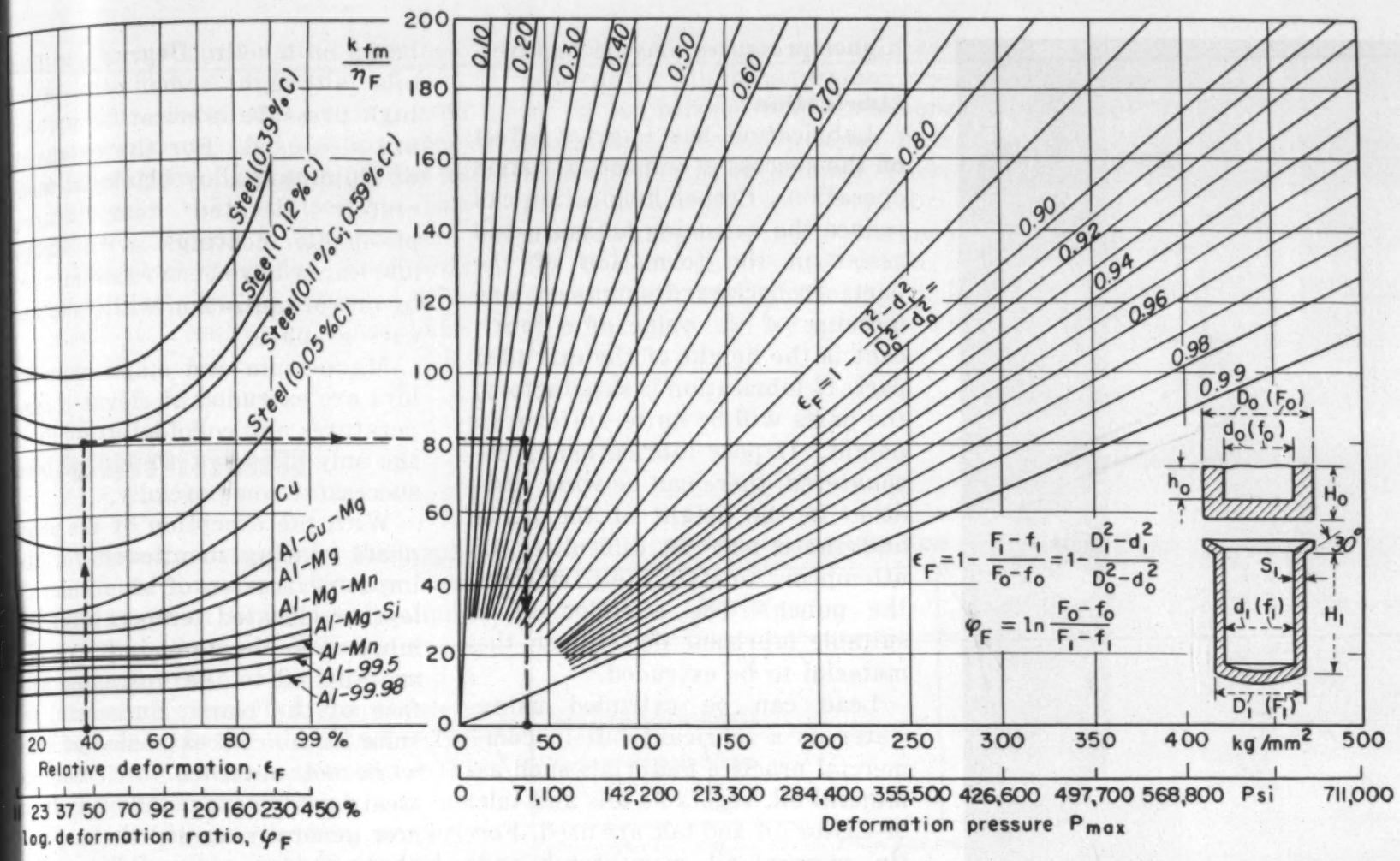
Relatively close tolerances can be maintained on wall and bottom thicknesses. As an example, walls 0.100 in. thick can be held to ± 0.010 in. readily. Walls over 0.15 in. might require ± 0.020 in. Diameters can generally be held to ± 0.010 in. Lengths require more latitude and may be ± 3/16 in.

As far as tool material selection is concerned, cold extrusion is quite similar to other processes involving plastic deformation. The blank is loaded in compression between the punch and die until the force is sufficient to deform it plastically, and it is then extruded either forward through the die or backward between punch and die. Forces acting on the tools thus consist of a pressure normal to the tool surface and a shearing force parallel to the surface.

From the point-of-view of the tools, the nearest approach to forward cold extrusion is cold drawing. However, the magnitude of the forces is much greater in extrusion because the blank, being stressed in compression, expands against the die walls and this additional pressure is added to that of the actual extrusion. In cold drawing, the material is stressed in tension and shrinkage reduces the pressure resulting from deformation.

To prevent collapse under the high pressures, surface hardness of the tools must be high, in the neighborhood of Rockwell C60 or higher, but the dies must also resist bursting stresses. It is necessary to balance the hardness, strength and toughness in selecting tools. However, tool design can influence resistance to bursting. Backing the hard tool steel die ring with a massive tough steel backing block into which the ring is shrunk, places the die ring in compression and improves resistance to bursting.

High carbon-high chromium tool steels are favored generally for impact extrusion of all materials. To meet the requirements of tooling for backward extrusion of steels, a suggested combination is a nitrided high carbon - high chromium steel for the punch and a die of non-deforming manganese steel shrunk into a nickel-chromium steel bolster. Others have indicated that solid tungsten carbide punches give excellent service in high speed mechanical presses. Some tool materials are listed in a table.



Nomograph for pressure required in forward extrusion. *(Adapted by H. J. Pessl from* Verein Deutscher Ingenieure, *Mar. 1953.)*

Extrusion pressures are a function of the projected area of the blank and the reduction of area in forming the part. They depend also on the yield point of the material and resistance to flow caused by the die. At relatively low speeds and little restriction to flow, as in a simple forward extrusion, the required tonnage can be based on the yield strength of the finished work-hardened part. At high speeds and greater restriction to flow, as occurs in backward extrusion, the load on the press may be three times the finished yield strength.

The effect of speed is a highly controversial subject with many opinions but few facts available. The limited experimental work which has been done on the effect of rate of straining on the extrusion pressures, indicates that higher rates of straining are distinctly beneficial in reducing the required pressure and the effect is most pronounced with the highest reductions in area. This effect may be due in part to the increase in heat of deformation with increasing reduction.

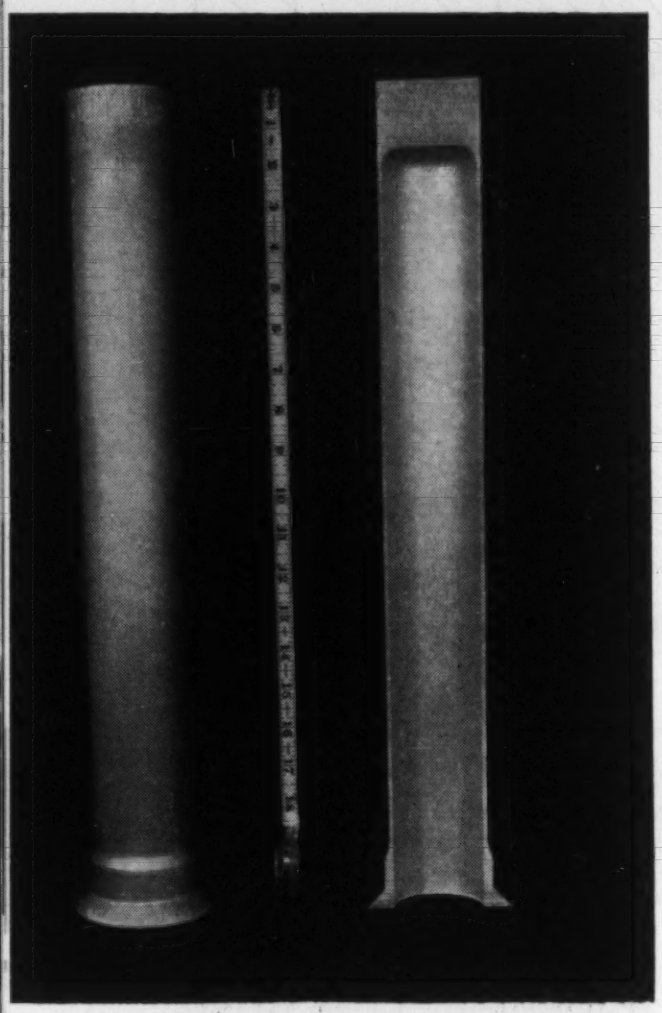
Various sources state that extrusion pressures required for aluminum and aluminum alloys range from 40 to 70 tons per sq in., for copper and brass the figures are 25 to 70 tsi, for low carbon steels the figures run from 65 to 200 tsi and for higher carbon and alloy steels considerably

PROPERTIES OF SOME PUNCH AND DIE STEELS

Composition—%							Typical Properties			Heat Treatment, F		
C	Mn	Si	Cr	W	Mo	V	Temper Temp, F	Diamond Pyramid Hardness	Rockwell Hardness	Anneal	Harden	Temper
1.45	0.35	0.20	0.80	4.25	—	—	300–575	870/690	C64/58	1475	1500 w q	300–575
1.60	0.30	0.20	0.60	5.50	—	—	300–575	870/690	C64/58	1475	1500 w q	300–575
2.30	0.35	0.30	13.0	—	—	—	As Harden'd	810/870	C62/64	1550	1775 o q	400–925
							400–925	810/610	C62/55			
1.65	0.45	0.30	13.0	—	0.70	0.30	As Harden'd	780/840	C61/63	1550	1875 o q	400–925
							400–925	780/610	C61/55		or a c	
1.00	0.40	0.20	1.45	—	—	—	350	810/870	C62/64	1475	1500 w q	300–575
1.00	0.70	0.20	1.45	—	—	—	350	750/810	C60/62	1475	1550 o q	300–575
1.00	2.00	—	2.00	—	1.00	—	200–575	840/715	C63/59	1575	1575 o q	200–575
2.40	0.40	—	12.75	—	1.10	4.00	400–925	780/715	C61/59	1625	1880 o q	400–925
1.00	0.35	0.40	6.25	—	1.00	—	300–575	810/671	C62/57	1550	1775 o q	300–575
0.92	1.25	0.25	0.45	0.45	—	—	As Harden'd	810/870	C62/64	1425	1425 o q	300–575
							300–575	810/690	C62/58			
0.92	1.15	—	0.50	0.50	—	0.20	200–575	810/671	C62/57	1425	1475 o q	200–575

w q = water quenched.
o q = oil-quenched.
c c = air cooled.

(William Jessop & Sons, Ltd.)



Aircraft landing gear component *produced by Harvey Aluminum from aluminum alloy 7075-T6. Length of impact extrusion 22 in., tolerance on wall thickness ±0.002 in. Since excellent surface finish is obtained on this product, only minor machining is required before the part is installed.*

higher pressures may be required.

Lubrication

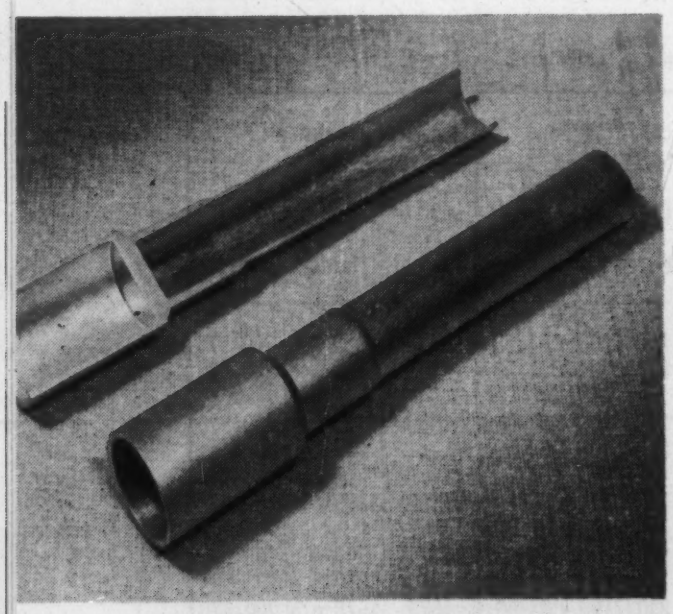
Lubrication has a great effect on the success of impact extrusion operations. Proper lubrication can reduce the extrusion pressure and assist in the formation of the part. In backward extrusion, one measure of the value of a lubricant is the height of the extruded part. If lubrication is satisfactory, the parts will be quite uniform in height. If poor lubrication is encountered, there can be wide variation in the height of the parts and there may be difficulties in attempting to strip the part from the punch. The selection of a suitable lubricant depends on the material to be extruded.

Lead can be extruded using water as a lubricant but in commercial practice materials such as mineral oil, vegetable oils and talc or castor oil and talc are used. For tin, mineral oil, corn starch and olive oil, or vegetable oil and talc are suitable.

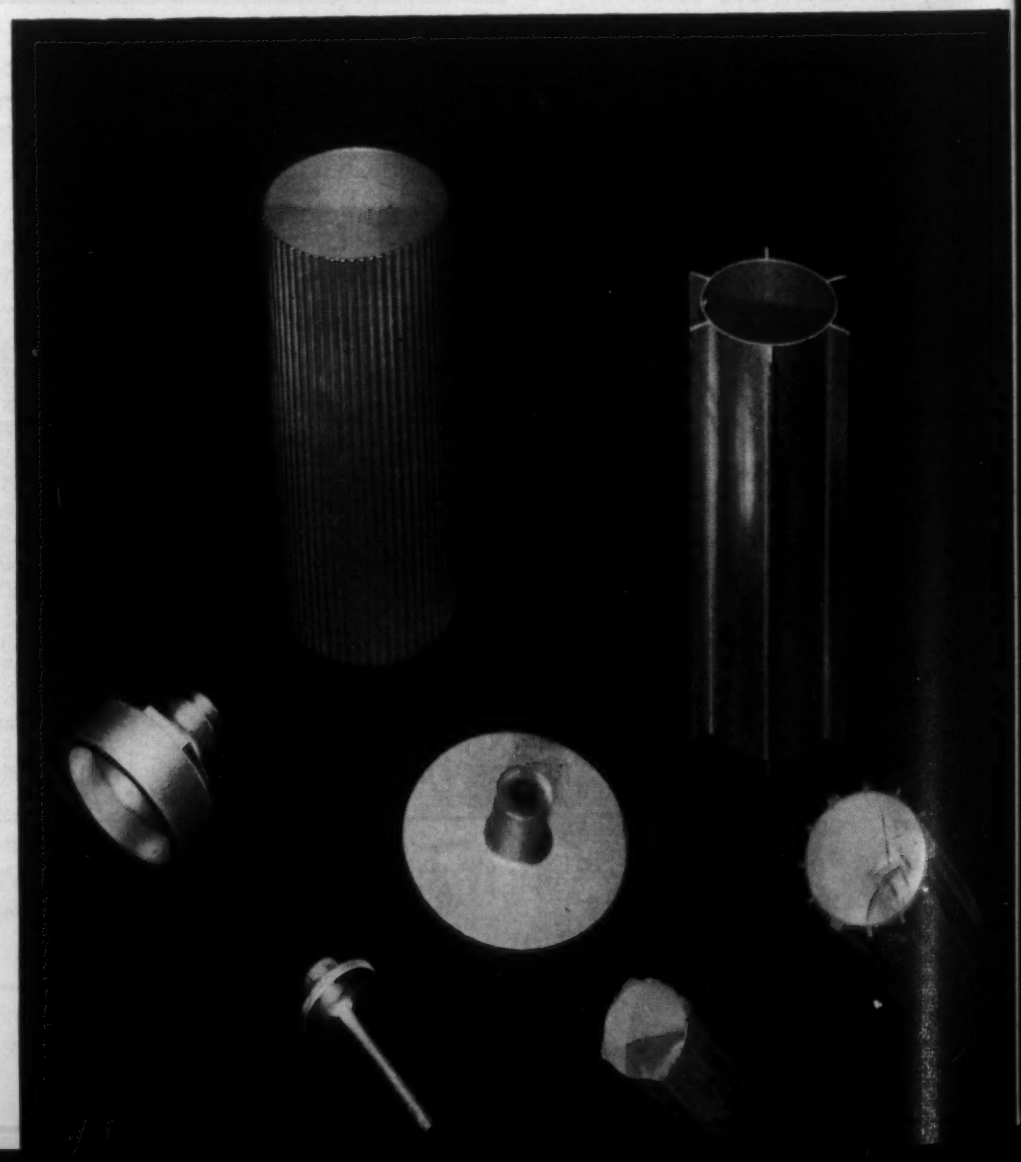
Lubricants for aluminum and aluminum alloys are generally based on lanolin, Degras and lard oils although some commercial high pressure lubricating greases are also used. For the extrusion of aluminum alloy blanks at moderately elevated temperatures, phosphate coatings with soapy lubricants have been recommended by one organization while another uses graphite.

Magnesium and magnesium alloys are extruded at elevated temperatures and colloidal graphite is the only lubricant which has been successful commercially.

With the exception of the phosphate coating mentioned for the impact extrusion of aluminum alloys at elevated temperatures, all lubricants mentioned previously are applied to the untreated surface of the blank. Successful results in the cold extrusion of steel were not obtained until surface treatments were employed. It is now generally agreed that a phosphate coating or a metallic coating such as copper is a necessary step in the process. This coating must be sufficiently durable to withstand pressures of 200,000



Ordnance component *requiring perfect seal from escape of high pressure gases produced by Hunter Douglas from aluminum alloy HD-11-T6 by impact extrusion replaced a three-piece assembly.*



Symmetrical parts *such as these present no particular production problems when produced from aluminum.* *(Aluminum Co. of America)*

psi for sufficient time to produce the product. As a matter of fact, the zinc phosphate coating used most commonly will last for several operations. This coating has no lubrication value in itself but does hold a lubricant on the surface.

For steel extrusion, lubricants containing polar groups give excellent results on phosphate-treated surfaces and among these lubricants sodium, potassium, resin or naphthene soap emulsions containing free fatty acids have been specifically mentioned. There are a number of proprietary lubricants which have been designed for use on phosphated surfaces from which the lubricating material is prepared by addition of water. Dipping the blanks in these hot solutions is the preferred manner of lubricating the blanks.

It is probable that suitable coatings or surface treatments will be evolved to permit the extrusion of other metals. Thus, zirconium can be impact extruded if the surface is jacketed with copper or aluminum before lubricating.

Aluminum

Greatest advances in the application of impact extrusion have been made in handling aluminum and its alloys. Not many years ago, only collapsible tubes and a few simple can-like shapes were produced from aluminum. The 1100 composition was used for the cans but this material was not pure enough to soften properly for collapsible tube use and a special grade, now known as 1170, was employed.

Today, parts are in production from almost a dozen aluminum alloys, including 2014, 3003, 6053, 6061, 6063, 6066, 6151, 7001, and 7075. An indication of relative extrudability follows: 1100 (best), 3003, 6061, 2014, 7075.

COMMERCIAL RANGES FOR ALUMINUM IMPACT EXTRUSIONS

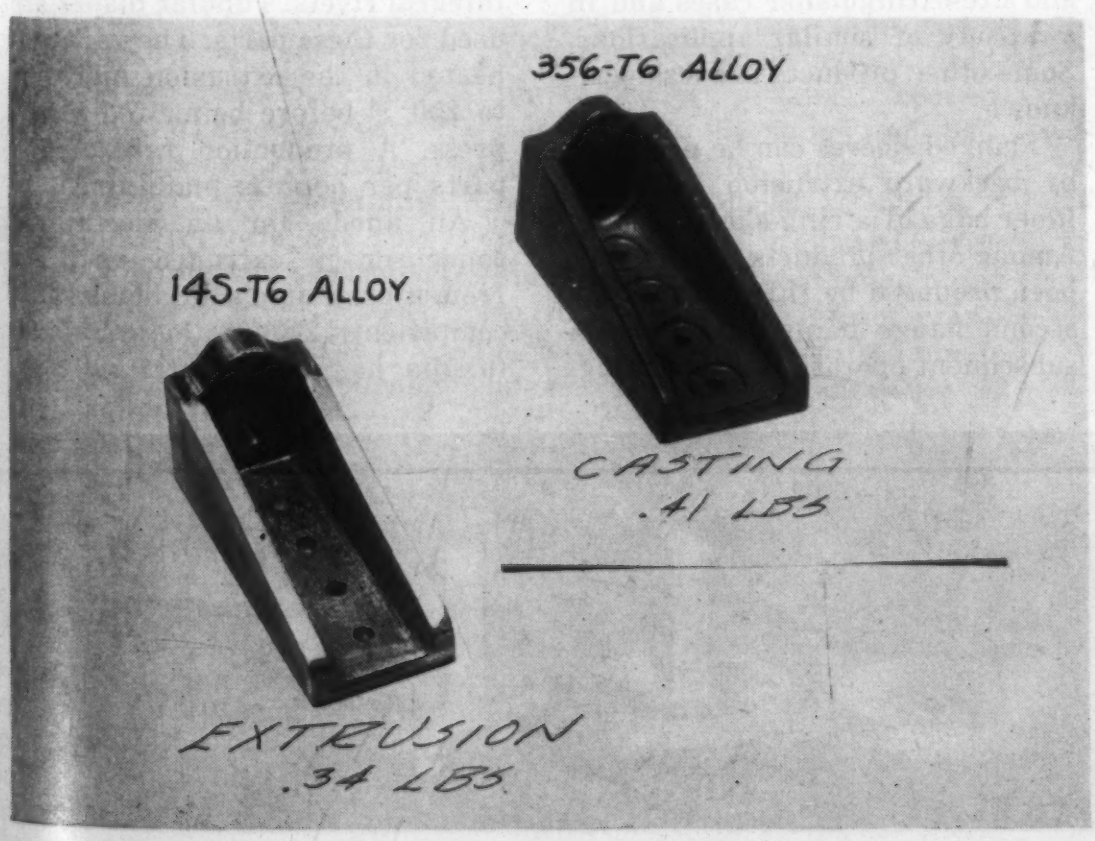
Material	Wall Thickness, in.		Diameter, in.	
	Max	Min	Max	Min
1070 (collapsible tubes)	0.010	0.0035	2½	⅜
1100 & 3003	½*	0.010	6	¼
Medium strength alloys	½*	0.040	5	¼
High strength alloys	½*	0.062	4	¾

* *Some authorities state that the maximum wall thickness is not known.*

These parts are used as components in various electronic, aircraft and automotive applications particularly. Specific examples will be discussed later. Parts up to about 18 in. in length have been produced by backward extrusion while 80 in. lengths have been produced by forward extrusion. An accompanying table gives an indication of the ranges of wall thicknesses and diameters available commercially.

There appears to be only one specification of national scope which covers impact extrusions. MIL-A-12545 (ORD) covers the aluminum alloys 1100, 2014, 6061, and 7075. No mechanical properties are specified for the parts "as extruded" but such properties are specified for heat treated parts produced from 2014, 6061 and 7075. These properties are practically the same as those required for forgings.

In most cases, aluminum blanks are not heated before being fed to the extrusion press. However, this does not imply that the operation is performed at room temperature. The frictional heat liberated during extrusion is sufficient to raise the temperature of the part and the tools several hundred degrees. The temperature does not



The weight saving *possible by impact extruding instead of casting a bracket is appreciable and would be even greater if the usual design factor of 1.3 for castings had been eliminated. The only machining required on the extruded part was tapering the sidewalls and drilling the holes.* (Lockheed Aircraft Corp.)

rise above the annealing temperature for any appreciable period since the parts formed exhibit cold-worked properties.

In the extrusion of the strong aluminum alloys, particularly 2014 and 7075, however, preheating slugs is often advantageous to reduce the force required to produce a part. Preheating is also said to increase the life of tools. The slug only is preheated and temperature should be held below 500 F to avoid defects such as cracking, tearing and even melting caused by work done during extrusion. The tools are not preheated usually since the work done warms them sufficiently.

Production rates are high for collapsible tubes and simple can-type parts running from perhaps 40 to 80 parts per minute. Rates vary greatly for the engineering components produced from the alloys. One company reports that the highest production rate is 45 parts per hour but qualifies the statement by reporting that the rate is governed by production requirements. Others report that rates running from 250 to 500 parts per hour are maintained without difficulty.

The mechanical properties of aluminum impact extrusions are equivalent to those of forgings produced from the same alloys. For example, a part produced from 1100 will have a tensile strength of 20,000 psi, a yield strength of 19,000, and an elongation of about 3%. Effect of impact extrusion on the properties of several alloys is given in a table. A producer of aircraft components states only that impact extruded aluminum parts can meet the requirements of MIL-A-12545, which, as mentioned previously, are practically the same as those for forged alloys of the same composition.

IMPROVEMENT IN PROPERTIES OF IMPACT EXTRUDED ALUMINUM ALLOYS

Alloy	Annealed		Extruded		Extruded & Heat Treated	
	Yld Str, psi	Ten Str, psi	Yld Str, psi	Ten Str, psi	Yld Str, psi	Ten Str, psi
1100	5000	13,000	19,000	20,000	—	—
3003	6000	16,000	30,000	32,000	—	—
2014	14,000	27,000	39,000	45,500	55,000	65,000
6061	8000	18,000	31,000	32,500	—	—
7075	15,000	33,000	41,300	47,500	70,000	78,000

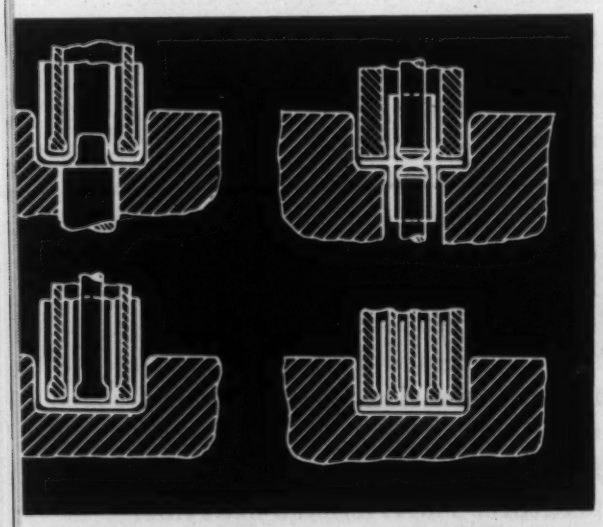
Applications

The production of round, oval, square and rectangular cross-section cans with or without lugs or reinforcing ribs has been discussed many times and is practiced widely. Such cans are used for medicinal vials, packaging food products, as condenser cans and fire-extinguisher cases and in a variety of similar applications. Some other products are less well-known.

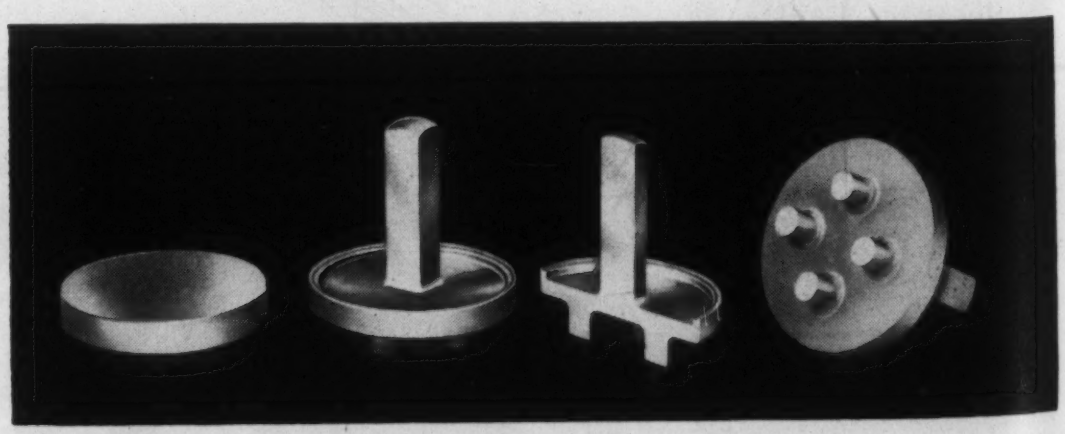
Flanged sleeves can be produced by backward extrusion from the inner edge of a ring-shaped blank. Among other products, spools have been produced by this method, the second flange being formed in a subsequent operation by spinning. Changing from drawing to impact extrusion saved five steps in the production of this part.

For the production of some complex parts, blanks or tools are preheated moderately to ease the extrusion. This procedure has been used in England for the extrusion of radio condenser components. An aluminum trimmer condenser is in production at the rate of 80,000 components per week. The stator is backward extruded with four concentric sleeves, the rotor with three. Wall-thickness of the sleeves is 0.014 in., the space between sleeves is 0.035 in. and the sleeve depth is 0.26 in. Three 0.060 in. dia projections forward extruded in the end faces, serve as integral rivets. Tubular blanks are used for these parts. They are preheated in the extrusion lubricant to 200 F before being fed to the press. A production rate of 750 parts per hour is maintained.

An anode for an electrolytic condenser is extruded similarly from a preheated solid blank. This component, 2⅝ in. long by 0.93 in. dia has 6 concentric sleeves.

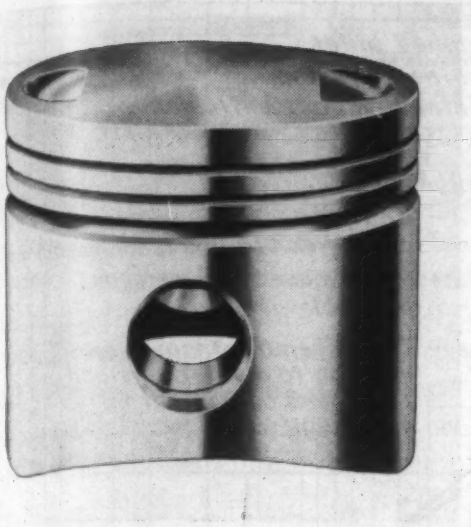


Aluminum is formed readily by impact extrusion and a variety of parts can be produced by suitably selecting the tools.

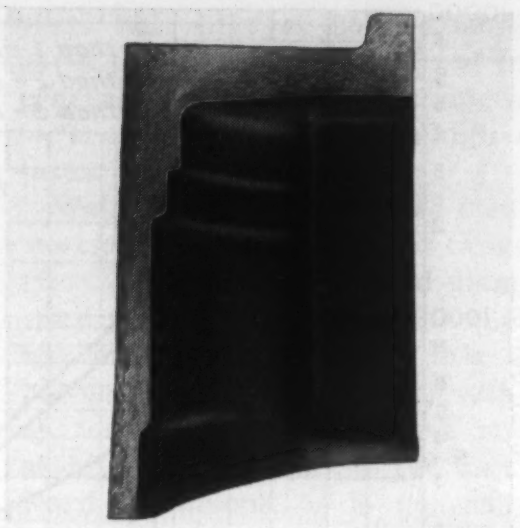


***Aluminum valve component** impact extruded in both directions from the slug shown at left. Diameter 3⅜ in., height of rectangular boss 3¼ in., diameter of round bosses on bottom ½ in., length 9/16 in.*

(Magnesium Co. of America)



Aluminum piston *produced from cast aluminum alloy blanks by impact extrusion weighs 30% less than conventional pistons and is much stronger.* *(Thompson Products, Inc.)*



Section through *an impact extruded aluminum piston before trimming and machining. Metal flow during extrusion yields a stronger piston than can be produced by conventional methods.*

(Thompson Products, Inc.)

Wall-thickness of the sleeves is 0.016 in. and they are spaced 0.05 in. apart.

An impact extruded bracket has been developed to replace a cast bracket with a resulting weight saving of 17%. The only machining required on the impact extruded part is tapering the sidewalls and drilling the holes.

Aircraft shear tie fittings are impact extruded from 5052 aluminum and the parts not only have irregular sides but also have varying wall-thicknesses. The extrusion is evolved by combining several fittings to form one part which is subsequently separated into the fittings.

Although it is the general rule that impact extrusions should have symmetrical cross-sectional areas, this is not strictly adhered to in some organizations. Production of asymmetrical parts has shown that the major penalty suffered by the producer of such parts is increased die cost. Parts open on one or two sides have been produced also.

Impact extruded pistons for automotive use are produced by extruding the aluminum alloy hot in a hot die. The operation however does not produce an annealed piston. Instead, the material is up to 50% stronger and 30% lighter than the cast alloy pistons in use at present. In addition, it is predicted that the output will be 5 times as great per man hour as obtained by present casting methods.

Other parts are produced by combining impact extrusion with subsequent operations. Thus, a panel mounting radio component is produced by extruding a can with a fairly thick bottom, heading to produce a flange, shearing the edges of the flange and drilling holes in the corners of the base thus produced. A bottle is produced by the backward extrusion of a can followed by spinning to form the neck. Impact extrusion is also used to eliminate stages in the deep drawing of various products. There are numerous possible combined operations of this type.

All preceding examples of applications are rather generalized. Some specific case histories of the advantages of impact extrusion follow.

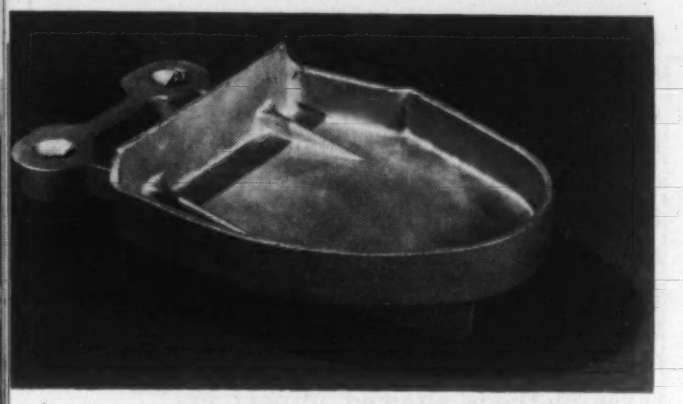
Three methods were available for the production of an aluminum alloy attachment bracket: machining, hot forging or impact extrusion. Machining from bar stock entailed difficulties in producing correct internal angles. Hot forging could be used but the draft required on both inside and outside faces and the flash formed during the operation required removal. By impact extrusion, both cavity and external geometry could be formed simultaneously in a hollow shape, the bracket being produced subsequently by splitting the extrusion into two parts. Cost comparisons between the three methods showed impact extrusions 39% cheaper than machining from bar stock, 10% cheaper than forging.

In the production of an ordnance component, a critical requirement was a perfect seal to prevent the escape of high pressure gases. As fabricated by conventional procedures, the component required the assembly of a screw machine part turned from bar stock and bored from each end, a sleeve machined from tubing and a Welsh plug. A single unit was formed by expanding the Welsh plug within the sleeve, forcing the walls into a machined groove within the head. To insure leak-proof construction and eliminate machining, an impact extruded part was designed for production from a high strength aluminum alloy. There are no joints and the part easily withstands bursting pressures of 5500 psi without distortion.

Latch bolts in modern door locks are customarily formed from a deep-drawn flanged barrel and two plates which are assembled and crimped to produce the part. Impact extrusion of the flange and barrel simultaneously from 1100 aluminum produced a part which, through cold working, acquired strength equal to that of the original assembly, and eliminated assembly of three components and a number of machining operations.

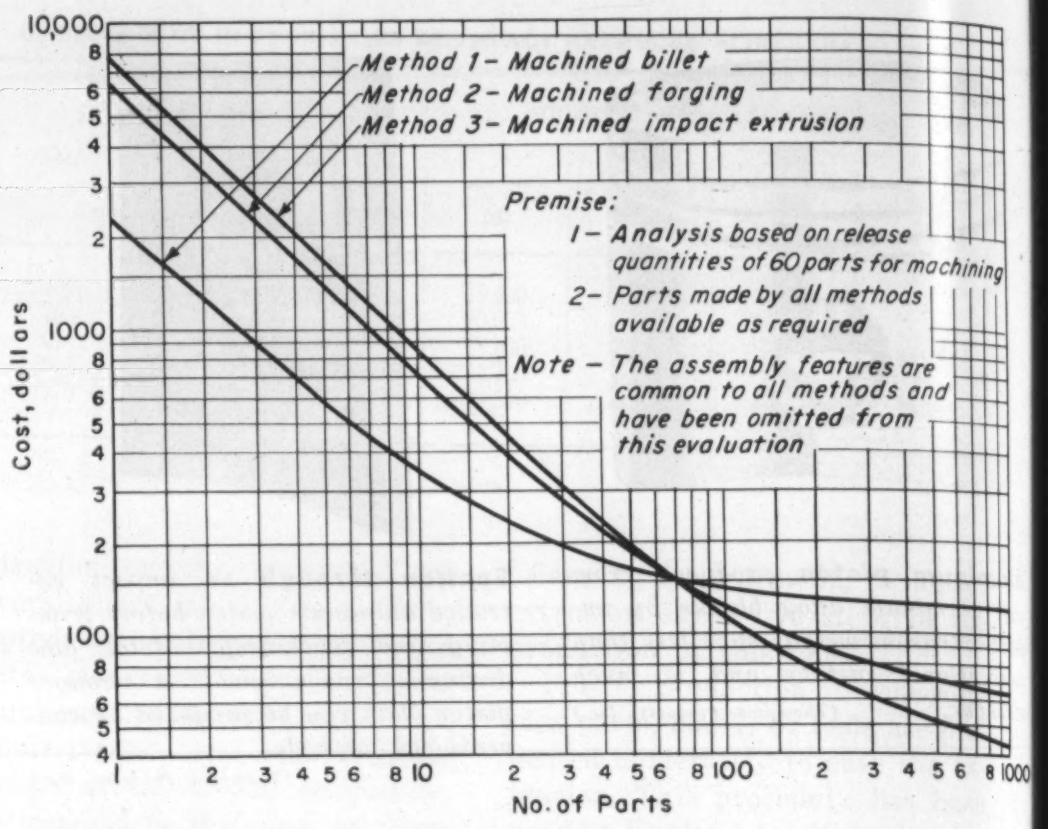
A torque tube collar, 2⅛ in. long by 2¼ in. o.d. having a flange 3-15/16 in. in diameter when produced from aluminum alloy sheet on regular punch press dies required 8 operations and cost $3.75 per piece in lots of 600. The same part produced by impact extrusion in lots of 600 cost $1.78 per piece.

A study on the relative costs of producing an aileron nose rib by machining from a billet, forg-



Nose rib assembly *proved by cost study to be cheaper to produce by impact extrusion than by either machining or forging.*

(Northrop Aircraft, Inc.)


Method 1 – Machined billet
Method 2 – Machined forging
Method 3 – Machined impact extrusion
Premise:
1 – Analysis based on release quantities of 60 parts for machining
2 – Parts made by all methods available as required
Note – The assembly features are common to all methods and have been omitted from this evaluation
Cost, dollars
No. of Parts

Cost of producing nose rib assembly by three methods.

ing and impact extrusion is shown in a figure. The material for billet and forging was 7075 while the impact extrusion was 2014. Curve 1 shows cost of machining from a billet, curve 2 is a conventional forging which requires machining of nearly all of the forging draft, while curve 3 is an impact extrusion which has little or no draft and requires machining only in the area of the bearings and for removal of a slight ridge. The risk of using impact extrusion becomes small since this is the cheapest method after only 68 parts have been produced. If 1000 parts are produced, impact extrusion costs only 35% of machining and only 67% of forging.

These examples are indicative of the possibilities of impact extrusion in the formation of parts from aluminum and its alloys. Accompanying photographs show examples of various applications and indicate the wide range of possibilities, of which the surface has barely been scratched. Aluminum appears to be particularly adapted to forming by this process.

Steels

The application of the impact extrusion process to steels was started in Germany about 20 years ago but was kept secret until after the war. Since that time the lead in the development of this process has been taken in America.

As applied to steel, the process is widely known as cold extrusion although it is actually one operation in a group which might with greater exactness be called heavy cold forming. The development which made this process possible was the discovery that a steel with a suitably prepared surface could be made to flow cold readily. At present the commercial method of accomplishing this objective is surface preparation by phosphate coating, usually with zinc phosphate. Application of a suitable lubricant, usually a high titre soap, to the treated surface permits the successful use of cold extrusion, sizing, coining, ironing, nozing and similar operations.

Structural condition of the steel is an important factor in extrudability. In general, a soft condition is desirable to reduce the pressures required. A structure containing fairly coarse spherodized carbide particles should require the lowest extrusion pressure for a given composition. It has been demonstrated that spherodized steels having carbon contents up to 1.2% can be cold extruded. However, a structure containing coarse spherodized carbides is impractical economically and does not yield the optimum combination of strength and ductility in the finished product. Therefore a compromise is prefered.

Uniform distribution of carbides throughout the structure will yield the best properties for a given carbide particle size. In one organization, good commercial results are obtained by soaking the steel above the critical temperature, quenching in water to retain a uniform carbide distribution and annealing at a suitable temperature to produce rapid softening but retain a fine grain size. Others report that low carbon steel in the form of hot rolled round bar stock is satisfactory for most products.

For optimum results, the hardness of the steel blank or slug should not be higher than Rockwell B-60. If harder steels are used, the reduction of area should be lowered correspondingly. Extrusion pressures increase also with the tensile strength. As a rough approximation, the extru-

sion pressure for a 65% reduction in area is 5 times the yield strength or 3 times the tensile strength of a normalized low carbon steel. Extrusion pressure also increases in almost direct proportion with the reduction, and one organization recommends that the reduction of cross-sectional area be limited to not more than 60% for the first stage and 40% for subsequent operations. Others use greater reduction and it is reported that the cold extrusion of a low carbon steel with a 75% reduction in area will require about 200,000 psi pressure if a suitable lubricant is used.

One producer states that the life of cold extrusion tools greatly exceeds that of hot forging dies. In the most severe backward extrusion, a carbide punch has produced 480,000 parts without measurable wear. Die rings are more rapidly worn out and need replacement at perhaps a tenth of that figure. Carbide is used when possible for punches and oil hardening tool steels for die rings. Some suggested compositions are given in a table.

Production rates are generally lower than they are for aluminum parts but rates of 250 or more parts per hour are maintained in general practice and some simple parts are produced at much higher rates.

Wall-thicknesses produced commercially in steel extrusions range from 0.035 to 0.875 in. and diameters from ¾ to 4⅝ in. although one producer states that this is not necessarily the limit. Lengths of forward extrusions have run as high as 80 in. while for backward extrusions, it is generally estimated that they will range up to about 4 times the diameter.

The cold extrusion process was originally limited to low carbon steels but even with these materials, improvement in mechanical properties, particularly yield strength, was remarkable. Yield strengths of better than 100,000 psi have been reported for cold extruded 1010 steel which, therefore, approaches the properties obtainable by heat treatment in many steels.

One expert considers that the approximate work-hardening effects on low and medium carbon steels are somewhat as follows:

Increases in hardness run from 60 to 130%, in tensile strength from 30 to 120%, and in yield strength from 100 to 300%. The great improvement in yield strength is particularly noteworthy. Accompanying the increase in these strength properties, the elongation is reduced by 40 to 90% and the reduction of area by about 20 to 60% as would be expected.

Development has proceeded to the point where some alloy steels are being extruded. Work by one producer indicates that AISI 1018, 5130, 8620, 8630, 4130, 4140, and 8730 appear to be as ductile and as readily extruded as 1010. For example, the yield strength of 8630 can be more than tripled with the retention of moderate ductility. The process has also been applied to both chromium and chromium-nickel stainless steels, although these materials do not appear to be as extrudable as the carbon and low alloy steels.

Applications

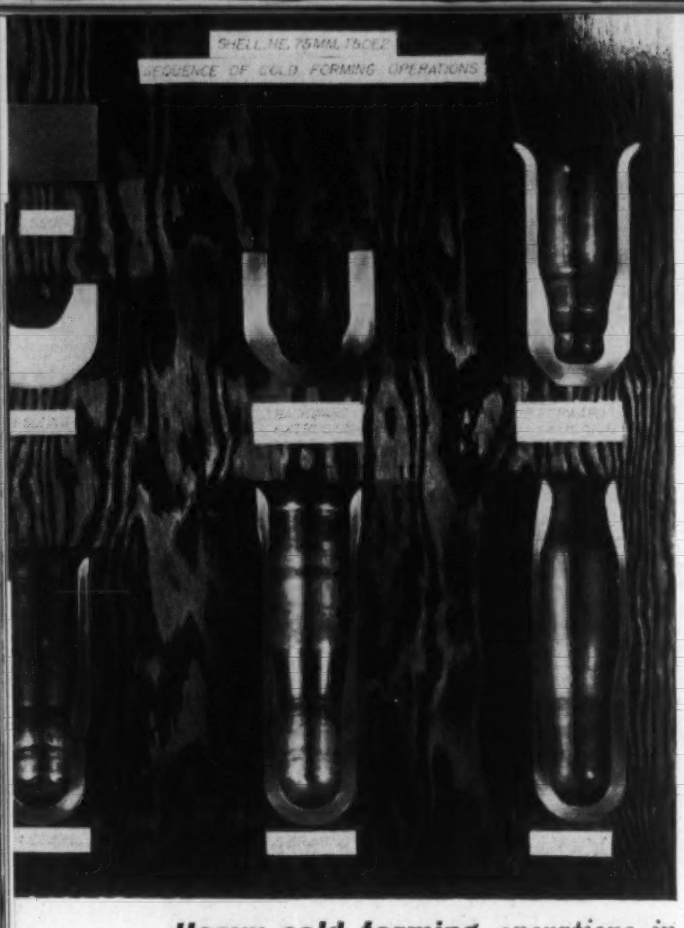
The cold extrusion of steel was originally developed for the production of ordnance components

DIE STEELS FOR COLD EXTRUSION OF STEELS

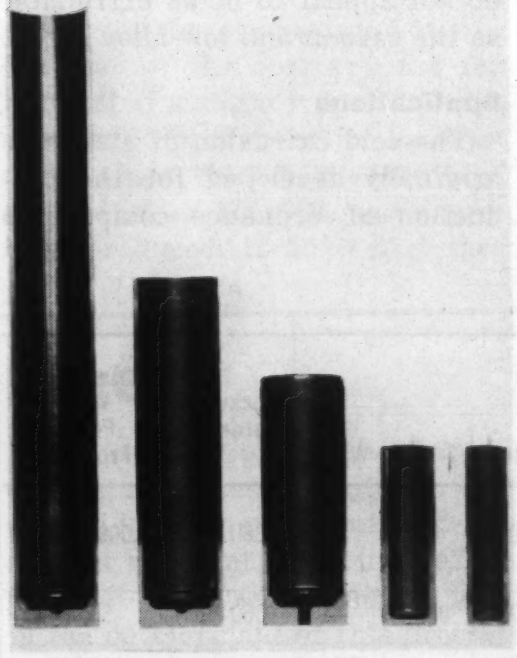
AISI-SAE Grade	Grouping	Application	Composition—% C	Si	Mn	Ni	Cr	Mo	V	W, Co	Rockwell Hardness	Average Work Pieces Produced
A2	Air hardening, medium alloy, cold work tool steel	Bushing or die inserts	1.0	—	—	—	5.0	1.0	—	—	C60–63	25,000–150,000
D2	Deep hardening, non-deforming, high carbon, high chromium, cold work tool steel	Medium stressed punches, bushings	1.60	0.35	0.40	—	11.50	0.75	0.40	—[1]	C60–63	50,000
D5			1.50	0.50	0.25	—	12.50	0.70	—	3.0	—	165,000
Special			0.85	0.35	0.40	1.05	11.50	0.50	0.30	—[2]	C61–62	—
M2	High speed tool steels	Most critical punches	0.80	—	—	—	4.0	4.75	1.80	6.0	C61–63	75,000
T1			0.70	—	—	—	4.0	—	1.0	18.0	C60–61	30,000
Special Die Steel	Ni-Cr-Mo	Bushings	0.55	1.0	0.90	2.70	0.40	0.45	0.12	—	C58–60	50,000–200,000
	Alloy steels	Sleeves	0.50	0.30	0.65	3.80	0.75	0.60	0.20	—	C58–60	30,000–100,000
S1	Shock resisting tool steel	Ejectors, shrink rings	0.50	—	0.80	—	1.50	—	—	2.50	C56–58	—
S5			0.50	2.0	0.80	—	—	0.40	—	—	—	—
L6	Special purpose tool steel		0.70	—	—	1.50	0.75	0.25 optional	—	—	—	—
W1	Water hardening, carbon or carbon vanadium tool steel	Die Fixtures	1.10	—	0.25	—	—	—	—	—	C60–63	—
W2			1.0	—	0.30	—	—	—	0.25	—	C60–62	—

[1] *Contains cobalt.*
[2] *Contains tungsten.*

(H. J. Pessl, Gibson Refrigerator Co., Private Communication, 1955)



Heavy cold forming *operations in the production of a 75mm shell include two cold extrusions, one backward and one forward.*
(Gibson Refrigerator Co.)



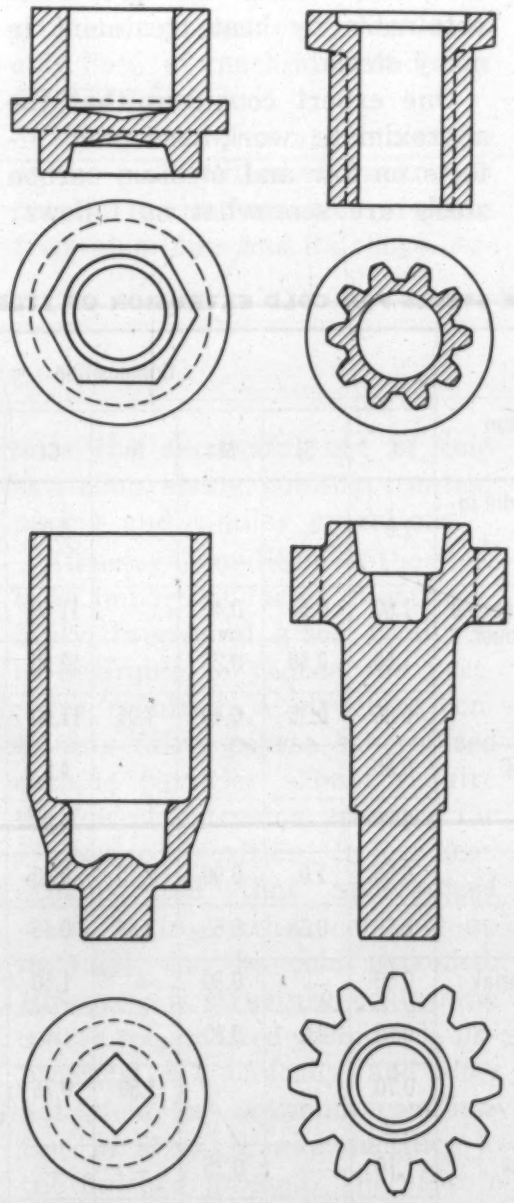
Carbon steel extrusions *can be made in a variety of sizes up to 42 in. long and 5⅜ in. in dia.*
(Mullins Manufacturing Co.)

and much of the effort put on it since the war has been in the same direction. Therefore most of the present applications lie in this field.

In the production of the 105-mm projectile, cold extrusion offers an improved product at substantial material and labor savings since the only machining required is the driving ring groove and finishing several holes. The process also yields a smoother, more concentric projectile than hot piercing and drawing. This shell is produced in 8 operations, a sizing operation is followed by three successive backward extrusions, an anneal and a forward extrusion. The remaining steps consist of expanding the lower part of the body and nozing.

To produce an 81-mm mortar shell, backward extrusion is combined with conventional deep drawing. After a sizing operation, the part is backward extruded with a reduction of 54% and the remaining operations are conventional redraws. Introduction of the backward extrusion operation eliminates one stage of redrawing.

The 75-mm shell for the "Skysweeper" anti-aircraft gun is now in production by cold extrusion methods. The shell is cold formed from C1018 fully aluminum-killed steel in six operations. After the first operation which is sizing, the formed blank is annealed at 1200 F. The shell is then backward extruded and again annealed at 1200 F. Succeeding operations, forward extrusion, coining, drawing and nozing follow and the finished shell is stress relieved at 750 to 850 F. Parts are produced at the rate of 250 per hour. This procedure saves considerable material and labor over the hot forging method also employed in the production of this shell.



Sketches indicating some of the shapes which have been produced by the cold extrusion of steel with or without supplementary operations.
(Heintz Manufacturing Co.)

Other ordnance parts cold formed by this method are rocket motors and heads. Progress is also being made in the production of non-military parts by this cold forming procedure although this development has lagged behind the ordnance program.

A high strength hydraulic cylinder having a finished weight of 2 lb is now being produced by cold extrusion from a 2.2 lb billet of 1015 steel. This part was formerly produced by the assembly and brazing of a tube and two end caps having a total weight of 2¾ lb, which was then machined all over. Savings by the new process amount to 30%.

A truck type differential gear which has been produced by hot forging and machining all over is now under production by cold forming methods with a cost saving of 20%. A billet of 8620 steel after cold extrusion requires only machining to face both ends, and cut a forked groove and a relief. Over-all savings in weight of the part are not great but a number of machining operations are eliminated. As an added advantage, the flow pattern of the grain produced by the new method conforms to the shape of the gear teeth and should improve the over-all strength of the part.

Among other parts which have been produced by the cold extrusion of steel, with or without supplementary operations excluding machining are shock absorber cylinders, gear blanks, hub and axle components, actuators, compressor pistons, hollow gears, starter gears and generator frames.

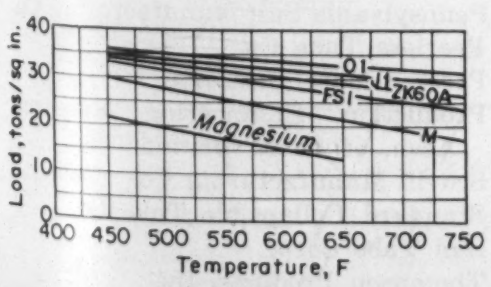
Magnesium

The impact extrusion of magnesium is a relatively recent development but considerable progress has been made. Originally limited to commercially pure magnesium, the process is now applied to a number of alloys also. A leading producer lists them in order of preference as AZ31B, ZK-60A, M1A, C, H, J1, O1, R followed by commercial magnesium. Several experimental alloys of the aluminum-zinc, zinc-zirconium and cerium-zirconium systems are also suitable but are less readily extruded than the grades listed previously.

The range of sizes available commercially at present is rather limited and depends on the alloy. However, wall-thicknesses ranging from 0.006 to 0.25 in. and diameters from about 1 to 6½ in. give an indication of the sizes in production. The ratio of length to diameter for a backward extrusion is about 8 to 1, while for forward extrusion the limiting factors are clearance required to remove the part and the size of blank required.

The structure of magnesium is such that the metal does not cold work readily. Thus the blanks must be warmed for the production of impact extrusions and working temperatures range from about 500 to 700 F. Pressure requirements are indicated in an accompanying figure.

In spite of the necessity of heating the blanks, however, production rates are comparable to those obtained in aluminum impact extrusion. Small parts up to 1¼ in. dia are regularly produced at the rate of 60 per minute and some have reached rates of 100 per minute. For larger parts, rates are somewhat lower; for example, 10 per minute for 3 in. diameter parts, and 5 per minute for 6 in. diameter parts.



Effect of temperature on the extrusion pressure required for various magnesium alloys. *(Dow Chemical Co.)*

PROPERTIES OF MAGNESIUM ALLOYS

Alloy	Treatment	Yld Str, psi	Ten Str, psi	Comp Yld Str, psi	Elong, %
AZ31A	Annealed	22,000	37,000	16,000	21
	Impact Extruded	28,000	43,000	23,000	18
	Regular Extrusion	29,000	38,000	14,000	15
ZK60A	Annealed	38,000	49,000	33,000	14
	Impact Extruded	34,000	46,000	28,000	16
	Regular Extrusion	38,000	49,000	33,000	14

Mechanical properties obtained in impact extruded magnesium alloy parts show a slight improvement over those of the original normal extrusions from which the parts are made. Properties of two alloys before and after extrusion are compared in a table.

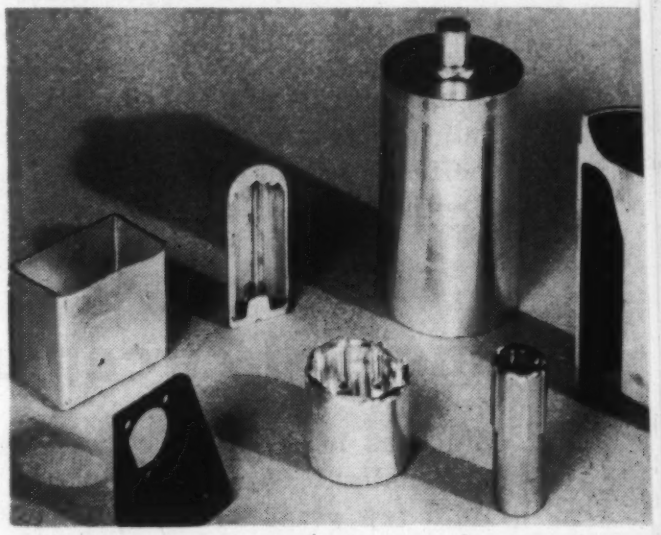
Applications

A more limited variety of parts is produced from magnesium and its alloys than from aluminum alloys. Most of them are can shaped with or without reinforcing ribs, internal bosses, etc. with circular, square or rectangular cross-sections.

A small triangular bracket, shown in an accompanying picture, was originally designed to be blanked from sheet stock, flanged, corners welded, stress relieved and sanded smooth. This part is now produced by impact extruding a rectangular cup which is cut into two triangular brackets at a considerable cost saving.

A magnesium can 1⅜ by 4 by 6½ in. having a sidewall thickness of 0.020 in. and a bottom thickness of 0.032 in. was produced in one operation. Finishing for an electronic application required only trimming to a length of 5⅝ in. and punching two mounting holes.

As an example of costs, one producer estimates that a simple round can 1 by 4 in. with a wall thickness of 0.040 in. which was set up for automatic production at the rate of 1000 per hour would cost 0.4¢ per piece (fabrication only) in a shop having a labor and overhead cost of $4 per man hour.



Magnesium and magnesium alloy *parts are produced by impact extruding at moderately elevated temperatures. Bracket in left foreground was produced by cutting a rectangular cup on a diagonal.* *(Dow Chemical Co.)*

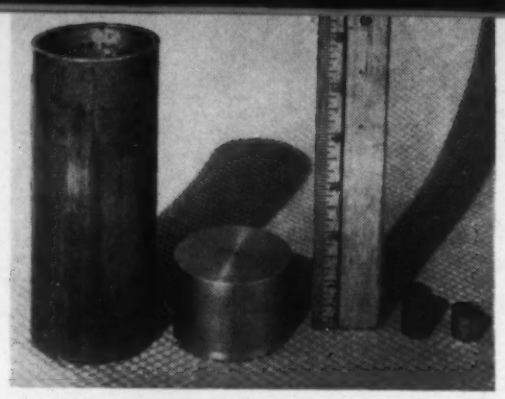
Lead and Tin

Alloys of these metals were the first to be impact extruded. They have been discussed frequently and their major application is collapsible tubes. Generally antimonial lead and copper-tin (1% copper) alloys are used for producing these products. Sizes range from about ⅜ to 3 in. in diameter and wall thicknesses from about 0.003 to 0.015 in. Output ranges from 40 to 80 tubes per minute.

Copper

Application of impact extrusion to copper and the copper alloys does not appear to be widely practiced at the present time. The process can be employed for the production of parts from all types of copper but oxygen-free or deoxidized copper are preferred to tough pitch because of somewhat superior ductility. The brasses can also be impact extruded although the low zinc brasses are more suitable than the high zinc grades.

The production of copper tubes by direct extrusion (the Hooker Process) is quite well known. By this procedure a preformed copper blank is extruded into tubes having either straight or tapered walls and either open or closed bottoms.



Heavy wall brass parts *produced by impact extrusion. Copper and brass parts offer a field which has not been widely exploited.*
(Scovill Manufacturing Co.)

Tubes 10 in. long with a wall-thickness of 0.006 in. are produced from a preformed blank 9/16 in. high, 7/16 in. dia and having a 1/10 in. wall. The reduction of area is 94% which is far greater than can be obtained in one operation by deep drawing where the usual limit is considered to be about 50% reduction.

Copper has also been backward extruded into a thin-walled rectangular can for a pocket lighter on an experimental basis. The load on the tools exceeded the theoretical breaking load considerably, indicating that much of the information available on impact extrusion is subject to revision when more data are available.

It appears that the impact extrusion has not received much consideration by the fabricators of copper and copper alloy parts and the field is wide open for exploitation. The process should be capable of reducing costs in this industry, if properly applied, just as it is doing in the light metals and steel fields.

Zinc and Zirconium

Zinc has been impact extruded into flashlight battery cases for quite a few years but the process does not appear to be used widely for other parts. High purity zinc (99.99% Zn) is the base material for most work although alloys containing 4 aluminum and 0.04% magnesium or small quantities of copper are also used.

In the production of parts from high purity zinc, annealed blanks having a Diamond Pyramid Hardness of 40 to 50 are used. These blanks are heated to about 200 to 250 F or in some cases as high as 350 F to improve the extrusion characteristics. Commercial parts run from 0.5 to 2.5 in. in diameter, from 2.5 to 3 in. deep for small diameters and up to 8 in. for large. Wall-thicknesses range from 0.020 to 0.14 in.

Among parts produced in addition to flashlight cans are various other round, square and rectangular cans usually without ribs. In general the parts are limited to the simplest shapes. They are used for automobile radio parts because the resonance is low and they can be soldered readily and for other types of electrical equipment, soft drink dispensers, noise filters, and advertising signs. Small gear blanks have also been produced.

Zirconium is structurally similar to zinc and is less readily cold worked than aluminum. Attempts to impact extrude zirconium at room temperature were unsuccessful. Backward extrusion at 900 F was somewhat more successful but not entirely. However, zirconium jacketed with aluminum or copper can be backward extruded at 900 F and cans up to 8 in. in length having wall thickness of 1/16 in. have been produced. The process is still in the experimental stages.

Parts such as these *are produced by impact extrusion of zinc.*
(Sun Tube Co.)

Acknowledgments

Much of the information included in this Manual was obtained from the personnel and publications of the following organizations. Their assistance is gratefully acknowledged.

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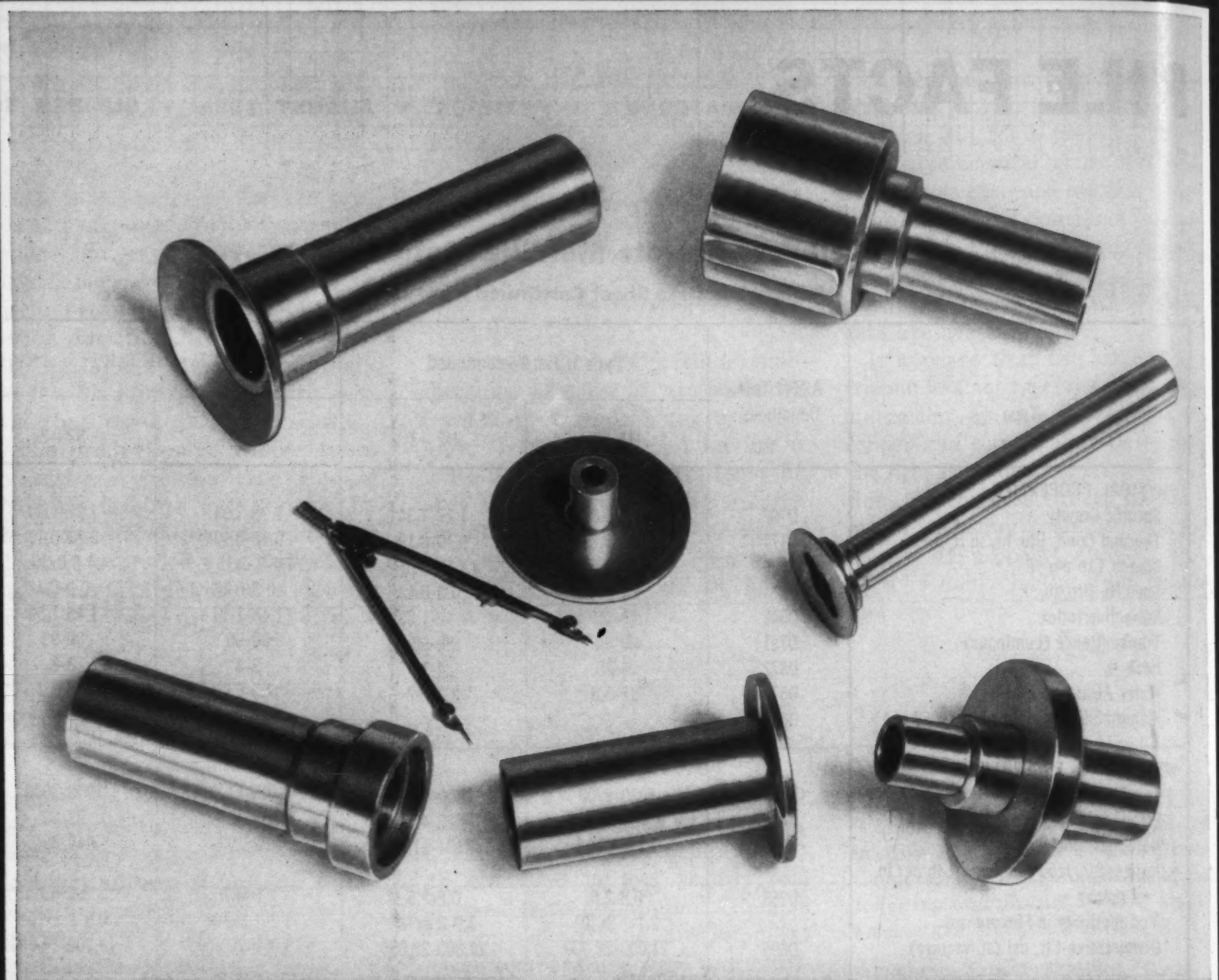
Cellulose Acetate Molding Materials

A Materials Data Sheet Continued from July

Type	ASTM Test Conditions	Type II Hard—continued		Type III Soft	
		H2—2	H2—3	S2—1	S2—2
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.28-1.33	1.27-1.34	1.28-1.34	1.27-1.30
Thermal Cond, Btu/hr/sq ft/ft/°F	C177	0.10-0.19	0.10-0.19	0.10-0.19	0.10-0.19
Coef of Exp per °F	D696	4.4-9.0x10^{-5}	4.4-9.0x10^{-5}	4.4-9.0x10^{-5}	4.4-9.0x10^{-5}
Spec Ht, Btu/lb/°F		0.3-0.42	0.3-0.42	0.3-0.42	0.3-0.42
Refractive Index	D542	1.46-1.50	1.46-1.50	1.46-1.50	1.46-1.50
Transmittance (Luminous)	D791	80-90	80-90	80-95	80-95
Haze %	D672	4-10	4-10	3-8	3-8
Water Absorption, 24 hr %	D570	2.2-3.8	2.2-2.7	2.3-6.5	2.6-5.7
Flammability in./min (over 0.050 in.)	D635				
MECHANICAL PROPERTIES					
Tensile Str, psi	D638	5000-6700	4600-6500	2400-4700	1900-3600
Elong, %	D638	17-40	22-40	34-49	32-50
Hardness, Rockwell	D785	R101-119	R101-118	R52-103	R49-86
Impact Str, Izod Notched (ft-lb per in. of notch)	D256	0.8-2.6	0.8-2.5	2.0-4.7	3.5-5.2
Mod Elasticity in Flexure, psi		2.1-2.8x10^5	1.9-2.8x10^5	1.2-2.5x10^5	0.9-1.3x10^5
Compressive Str, psi (at fracture)	D695	21,000-28,000	24,000-28,000	13,000-20,000	13,000-14,000
ELECTRICAL PROPERTIES					
Elect Res, ohm-cm	D257	10^{10}-10^{13}	10^{10}-10^{13}	10^{10}-10^{13}	10^{10}-10^{13}
Dielectric Str (Short Time) volts/mil	D149	250-365	250-365	250-365	250-365
Dielectric Constant:					
60 cycles	D150	3.5-7.5	3.5-7.5	3.5-7.5	3.5-7.5
1,000,000 cycles	D150	3.2-7.0	3.2-7.0	3.2-7.0	3.2-7.0
Loss Factor:					
60 cycles	D150	0.03-0.38	0.03-0.38	0.03-0.38	0.03-0.38
1,000,000 cycles	D150	0.03-0.33	0.03-0 33	0.03-0.33	0.03-0.33
FABRICATING PROPERTIES					
Injection Molding Pressure, psi		8000-32,000	8000-32,000	8000-32,000	8000-32,000
Injection Molding Temp, F		390-460	390-460	335-395	335-395
Compression Ratio (Bulk Factor)		2.0-2.6	2.0-2.6	2.0-2.6	2.0-2.6
Compression Molding Pressure, psi		500-5000	500-5000	500-5000	500-5000
Compression Molding Temp, F.		320-370	320-370	260-310	260-310
Extruding Temp, F		390-420	390-420	335-365	335-365
MAXIMUM RECOMMENDED SERVICE TEMP, F.		Since these are thermoplastic materials they gradually become softer as the temperature rises. The maximum service temperature will depend on such factors as formula, design of part, humidity, service conditions, etc.			
CORROSION RESISTANCE		Unattacked by water, salt water solutions, white gasoline, oleic acid, 5% acetic acid; dilute sulfuric acid; decomposed by 30% sulfuric, 10% nitric, 10% hydrochloric acids, sodium hydroxide, 10% ammonium hydroxide; dissolved by acetone and ethyl acetate.			
USES		Automotive and radio knobs, tool handles, business machine keys; electrical items such as fluorescent lamp supports, coil spools and contact bases; toys and novelties; sun glass goggles and frames, spectacle frames; buttons and tags.			

Prepared with the assistance of the Manufacturing Chemists' Association, Inc.
Based on the Chemists' Association publication, "Technical Data on Plastics", 1952

For more information, turn to Reader Service Card, Circle No. 464



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Standard Types of Stainless and Heat Resisting Steels

CHEMICAL RANGES AND LIMITS

Type Number	Chemical Composition, %								
	C	Mn Max	P Max	S Max	Si Max	Cr	Ni	Mo	Other
301	0.15 Max	2.00	0.045	0.030	1.00	16.00-18.00	6.00- 8.00		
302	0.15 Max	2.00	0.045	0.030	1.00	17.00-19.00	8.00-10.00		
302B	0.15 Max	2.00	0.045	0.030	2.00-3.00	17.00-19.00	8.00-10.00		
303	0.15 Max	2.00	0.20	0.15 Min	1.00	17.00-19.00	8.00-10.00	0.60* Max	Zr: 0.60* Max
303 Se	0.15 Max	2.00	0.20	0.06	1.00	17.00-19.00	8.00-10.00		Se: 0.15 Min
304	0.08 Max	2.00	0.045	0.030	1.00	18.00-20.00	8.00-12.00		
304L	0.03 Max	2.00	0.045	0.030	1.00	18.00-20.00	8.00-12.00		
305	0.12 Max	2.00	0.045	0.030	1.00	17.00-19.00	10.00-13.00		
308	0.08 Max	2.00	0.045	0.030	1.00	19.00-21.00	10.00-12.00		
309	0.20 Max	2.00	0.045	0.030	1.00	22.00-24.00	12.00-15.00		
309S	0.08 Max	2.00	0.045	0.030	1.00	22.00-24.00	12.00-15.00		
310	0.25 Max	2.00	0.045	0.030	1.50	24.00-26.00	19.00-22.00		
310S	0.08 Max	2.00	0.045	0.030	1.50	24.00-26.00	19.00-22.00		
314	0.25 Max	2.00	0.045	0.030	1.50-3.00	23.00-26.00	19.00-22.00		
316	0.08 Max	2.00	0.045	0.030	1.00	16.00-18.00	10.00-14.00	2.00-3.00	
316L	0.03 Max	2.00	0.045	0.030	1.00	16.00-18.00	10.00-14.00	2.00-3.00	
317	0.08 Max	2.00	0.045	0.030	1.00	18.00-20.00	11.00-15.00	3.00-4.00	
321	0.08 Max	2.00	0.045	0.030	1.00	17.00-19.00	9.00-12.00		Ti: 5xC Min
347	0.08 Max	2.00	0.045	0.030	1.00	17.00-19.00	9.00-13.00		Cb-Ta: 10xC Min
348	0.08 Max	2.00	0.045	0.030	1.00	17.00-19.00	9.00-13.00		Cb-Ta: 10cC Min Ta: 0.10 Max
403	0.15 Max	1.00	0.040	0.030	0.50	11.50-13.00			
405	0.08 Max	1.00	0.040	0.030	1.00	11.50-14.50			Al: 0.10-0.30
410	0.15 Max	1.00	0.040	0.030	1.00	11.50-13.50			
414	0.15 Max	1.00	0.040	0.030	1.00	11.50-13.50	1.25- 2.50		
416	0.15 Max	1.25	0.06	0.15 Min	1.00	12.00-14.00		0.60* Max	Zr: 0.60* Max
416 Se	0.15 Max	1.25	0.06	0.06	1.00	12.00-14.00			Se: 0.15 Min
420	Over 0.15	1.00	0.040	0.030	1.00	12.00-14.00			
430	0.12 Max	1.00	0.040	0.030	1.00	14.00-18.00			
430F	0.12 Max	1.25	0.06	0.15 Min	1.00	14.00-18.00		0.60* Max	Zr: 0.60* Max
430F Se	0.12 Max	1.25	0.06	0.06	1.00	14.00-18.00			Se: 0.15 Min
431	0.20 Max	1.00	0.040	0.030	1.00	15.00-17.00	1.25- 2.50		
440A	0.60-0.75	1.00	0.040	0.030	1.00	16.00-18.00		0.75 Max	
440B	0.75-0.95	1.00	0.040	0.030	1.00	16.00-18.00		0.75 Max	
440C	0.95-1.20	1.00	0.040	0.030	1.00	16.00-18.00		0.75 Max	
446	0.20 Max	1.50	0.040	0.030	1.00	23.00-27.00			Ni: 0.25 Max
501	Over 0.10	1.00	0.040	0.030	1.00	4.00- 6.00		0.40-0.65	
502	0.10 Max	1.00	0.040	0.030	1.00	4.00- 6.00		0.40-0.65	

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Source: American Iron and Steel Institute, April 1955

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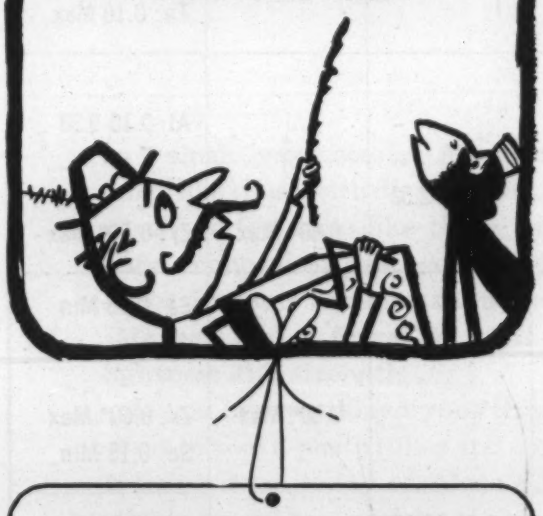

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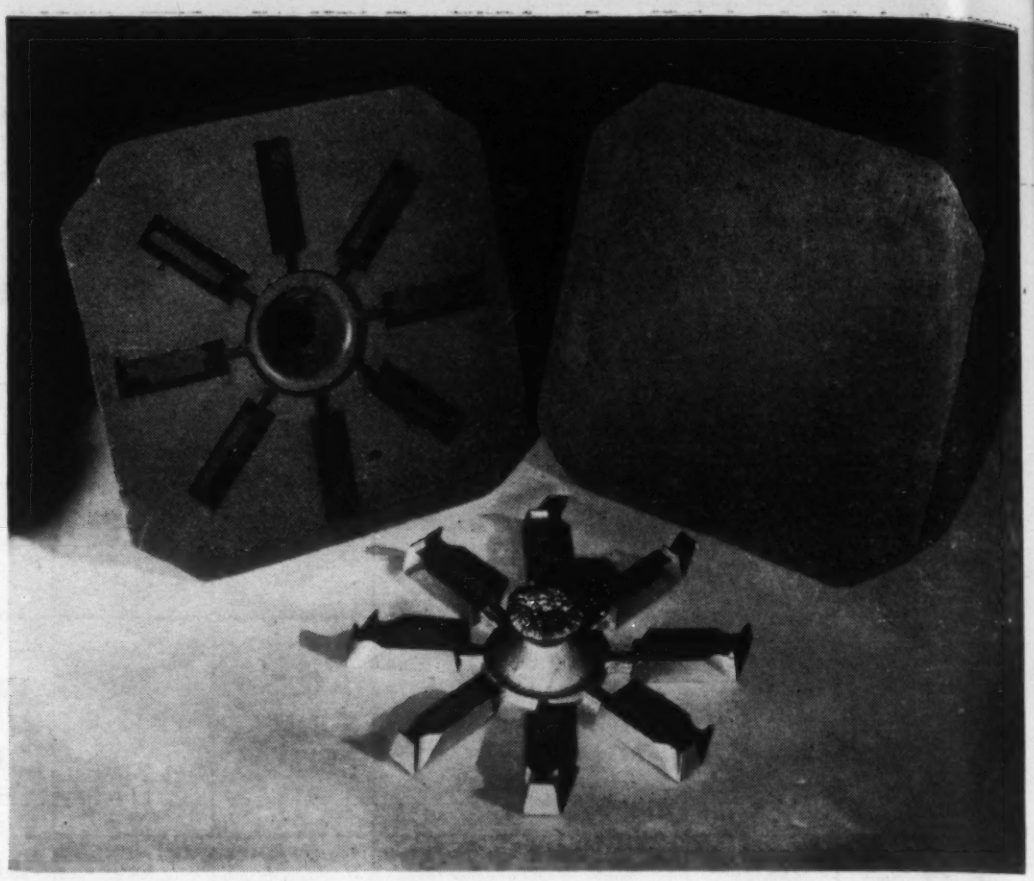


Copper chill blocks *for submerged arc welding are shell molded at 1/12 the cost of part made by machining.*

Shell Molded Production Tools Use Scrap Metal

Shell molding proves successful for small quantity production. Higher costs of method are repaid by savings in machining and finishing.

by Kenneth Rose, *Midwestern Editor, Materials & Methods*

■ Shell molding is being successfully applied at the Buick Division of General Motors Corp. for production tools such as chill blocks and electrodes for welding, heat treating trays and high speed steel tools. In all of these shell molding operations, scrap metals are used for either the entire heat or for at least part of it. The scrap materials are often broken or worn parts of the same kind as those being poured.

Welding blocks and electrodes

Copper chill blocks are used in the submerged arc welding of rear axle housings. They are about 4 in. long and are beveled on both ends to facilitate fastening into the welding fixture. One end is also notched to provide clearance. These chill blocks must be replaced frequently and when machined from bar copper, they require about 1 hr each to produce.

The blocks are now made by shell molding sixteen at a time. The pattern is made in steel. The castings have a surface sufficiently smooth to eliminate all need for machining. It is estimated that chill bars, produced as shell moldings, cost only about one-twelfth as much as when machined from bar copper. Inasmuch as 500 pieces may be made up for a single order, the over-all savings are considerable.

Small resistance welding elec-

Heat resistant alloy trays, *produced by shell molding, are used in annealing of forgings.*

trodes for the welding of nuts in position are also being shell molded because the shape of the piece does not lend itself to rapid machining. They have locating projections along two sides and require a hardened copper alloy of good conductivity.

A copper-beryllium alloy, made by mixing readily available monel scrap with a master alloy containing 4% beryllium, has been found satisfactory for the part. The castings produced are heat treated to develop a hardness of 98 to 100 Rockwell B. The boss holding the electrode in the welder is turned down in a lathe to provide good contact. This is the only machining required to make the electrode ready for service.

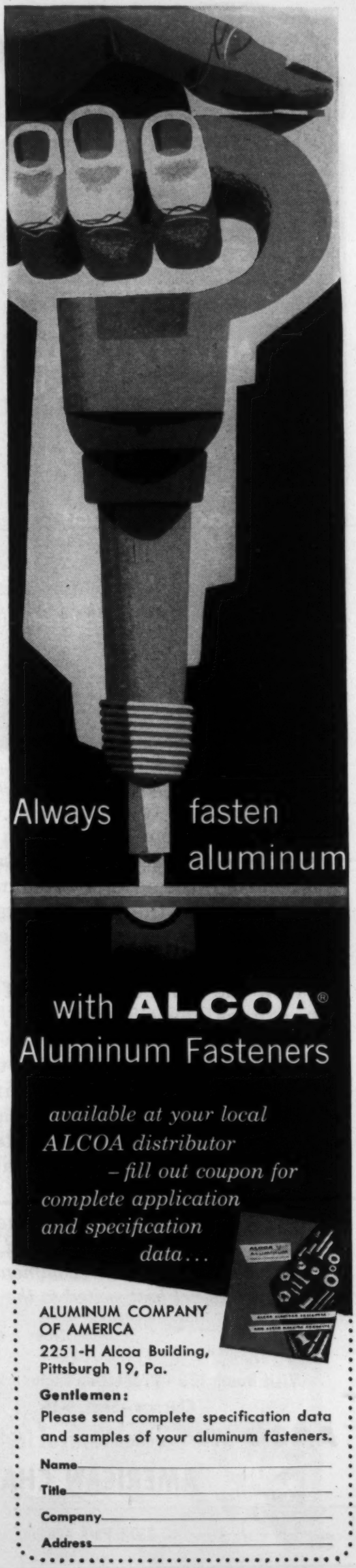
Several other forms of welding electrodes for projection welding of nuts are also being shell molded in beryllium copper. They are all small, weighing only a few ounces each, and most of these have a shape that makes machining somewhat complicated. By shell molding, the electrode is produced with a surface sufficiently smooth to eliminate machining except over the boss that attaches the electrode to the welder. Another chill block is wedge-shaped, with a slightly rounded surface over one side—a difficult form to machine. This also has been shell molded to eliminate machining.

Trays and cutting tools

In addition to the copper and copper alloy pieces, a high-alloy tray for heat treating is being shell molded. This tray is used in the annealing of forgings. The alloy used is a 35-15 heat resisting alloy, with a nominal composition of 35% nickel, 15% chromium, balance iron. The tray as-cast, with attached gates and risers, weighs about 10 lb, and the trimmed casting weighs about 7 lb. Eight trays can be poured per heat from a 100-lb electric furnace.

Still in the development stage is the shell casting of high speed single point cutting tools. Several lots of test tools have been cast and subjected to production tryout during the past several months. However, adjustment and control of composition present problems which remain to be solved before the process can be considered successful.

For experimental castings, an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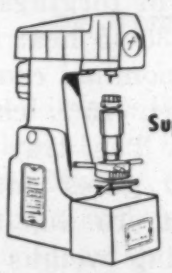

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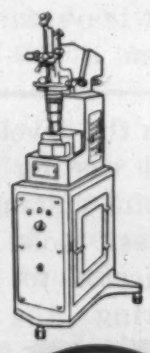

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attempt is made to use the part itself as a pattern, and to make up molds as dry sand molds with a resin binder rather than as true shell molds. When the process has proved its feasibility, steel patterns are made and true shell molding is used. A system of attaching the smaller patterns to a plate by machine screws permits flexibility in production, and a good rate of production.

Copper and copper alloys are cast in a sand with 20% silica added, and with 8% resin binder. Shells are joined by adhesive bonding. The silica improves the surface in the casting, and helps reduce the tendency toward burn-in. The alloys are poured at 2250 F.

For the high speed steel and heat resisting alloys, the sand is bank sand (containing less than 5% clay-like material) with about 6% resin. Although the trend in shell molding has been to use silica sand (99% pure silica) to improve finish by preventing burn-in, bank sand has proved quite satisfactory for these high melting alloys because it has excellent hot strength and is relatively inexpensive. With 35-15 alloys, pouring starts at 3050 F and is completed at 2900 F.

The entire shell molding operation for production of these tools uses equipment adapted from laboratory or other small scale processes. Small electric furnaces of the laboratory type are used for melting the metals. As a result, the investment, usually important even for a small shell molding system, is inconsequential. Production is low, of course, but is sufficient to show savings of thousands of dollars.

Now
U.S. DEFENSE BONDS
EVEN BETTER

New Materials, Parts and Finishes | and related equipment

These properties . . .

Analysis—46 Al_2O_3, 51% SiO_2 bal approx 3% Fe_2O_3 an TiO_2

Melting Point, 3200 F

Use Limit 2000 F continuous
2300 F short periods

Average Fiber Dia 3 microns (0.00012 in.)

Bulk Density 3 to 10 lb/cu ft

Thermal Conductivity at various temperatures and bulk densities, Btu/hr/sq ft/°F/in.*:

Mean Temperature	3 lb/cu ft	5 lb/cu ft	10 lb/cu ft
400 F	0.52	0.46	0.38
600 F	0.80	0.63	0.51
800 F	1.15	0.94	0.66
1000 F	1.64	1.29	0.83

Pressure drop through clean pad, in. H_2O/in. thickness:

Air Velocity	3 lb/cu ft	4 lb/cu ft	5 lb/cu ft
20 ft/min	0.20	0.24	0.27
50 ft/min	0.72	0.88	1.02
70 ft/min	1.25	1.55	1.85

** Values given are for bulk wool randomly packed. Because of better orientation of fibers, values for the blanket are substantially lower than this.*

. . . make blanket insulation useful at temperatures up to 2000 F

Fibrous insulation in the form of a self-supporting blanket has been developed for continuous use at temperatures up to 2000 F. Kaowool, an alumina-silica fiber developed by *Babcock & Wilcox Co.*, 161 E. 42nd St., New York 17, previously has been available only in bulk form. Recent manufacturing developments have resulted in production of a flexible blanket with longer, stronger and finer fibers and a greatly reduced shot or unfiberized particle content.

Properties

The material is available in pilot plant quantities in thicknesses from ¼ to 3 in., in widths up to 28 in., and in bulk densities ranging from 3 to 10 lb per cu ft. Properties such as insulating valves and filtration characteristics are dependent on bulk density and are shown in the table.

Though kaolin, from which Kaowool is made, melts at temperatures as high as 3200 F, Kaowool fibers are in a non-crystalline form. At high temperatures for extended periods of time, the fibers gradually become crystalline and more brittle. When completely crystallized, they fall to powder under vibratory action or physical deformation. Temperature limitations on use depend on time at temperature as well as what is considered to be too crystalline to be useful. Since Kaowool has been held for over 6 mo at 2000 F and still retained high resilience, its continuous use limit is considered to be 2000 F.

Applications

B & W expects wide application of the material in uses such as the following:

1. Aircraft—Insulation for jet engines and in construction of fire-resistant walls and baffles.
2. Fire-resistant construction—Insulation inside metal wall, floor and ceiling panels where insulation will stop the spread of fire. Also in domestic equipment such as incinerators, house furnaces, stacks, etc.
3. Miscellaneous insulation—In areas where facilities have not been available for holding or maintaining bulk Kaowool in position. These would include blankets for temporary heating enclosures, back-up insulation for furnaces and turbines, portable insulation, and insulation around odd shapes.
4. Water and steam tubes—Back-up behind water and steam tubes where occasional by-passing or leakage of hot furnace gases may go beyond limits of asbestos, glass or rock wool.
5. Filters—High temperature filters for control of air pollution as in the steel industry or chemical recovery in the chemical process industries.
6. Acoustics—Acoustical treatments as in exhaust stacks of diesel and other internal combustion engines.

(See also p. 214 in July M & M)

***New insulation** is useful at temperatures met in Pratt & Whitney's J-48 Turbo-Wasp.*

Free flowing *Nylon 8 can be processed in liquid form.*

New Nylon Formulation Has Versatility

Features claimed for a new Type 8 nylon formulation include 1) flexibility without plasticizers, 2) high strength, toughness and flex durability, 3) high abrasion resistance, elongation and elastic recovery, 4) low brittleness temperature and 5) high resistance to most solvents, alkalies, oxygen and ozone. The material is being marketed by *Belding Corticelli Industries, Inc.*, 1407 Broadway, New York 18, under a licensing agreement with E. I. du Pont de Nemours and Co.

Type 8 resins can be applied from alcohol solution, molded, milled and calendered. They offer a wide range of color possibilities since they accept certain classes of dies readily and are well adapted to pigmentation techniques. Molding powders are available, both unpigmented and in a limited number of colors under the designation FM-8001.

TYPICAL PROPERTIES OF TYPE 8 NYLON (RESIN DV-55)
(Uncured And Cured With Citric Acid, pH4)

	Uncured	Cured at 250 F for 30 min	Cured at 280 F for 5 min
Tensile strength, psi			
dry, 50% R.H.	2950	8070	7650
water-saturated	730	4440	
Ultimate elongation, %			
dry, 50% R.H.	675	415	
water-saturated	550	340	
Load at 100% elongation, psi			
dry, 50% R.H.	1450	3550	3450
Tear strength, Elmendorf units/mil/2-in. tear			
dry, 50% R.H.	14.1	2.5	
Cold-crack temperature, F	—40	—30	
Softening point, F	284	>300	>300
Water-absorption at saturation, %	21	11	
Moisture vapor-transmission, 25 C, oz/sq ft/24 hr	0.9 (6 mil film)	0.5 (7 mil film)	
Solubility in methanol and ethanol	soluble	insoluble	insoluble
Resistance to boiling water	gelatinizes	o.k.	o.k.
Clarity of film	clear	clear	clear
Color of film	colorless	colorless	very slightly yellow

Note: Data obtained using one lot of resin.
Unless otherwise specified, all determinations were made on 5 to 6 mil solvent-cast film.

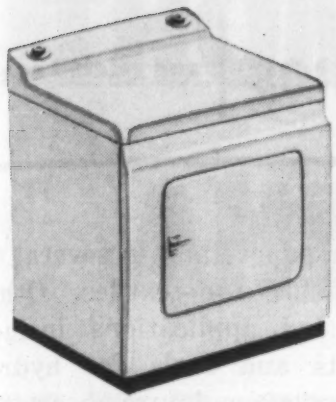
Properties

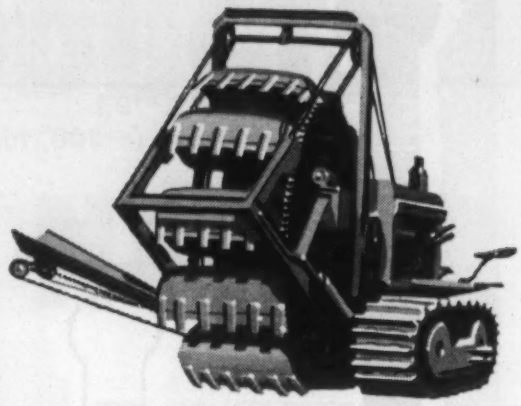
The accompanying table lists typical properties of a Type 8 nylon resin both cured and uncured. The resins are said to have high resistance to hot or cold aqueous alkali solutions, and to oxygen-containing gases. They decompose in formic and acetic acids and in strong mineral acids. Prolonged exposure to weak organic acids alters their properties. According to Du Pont, they are insoluble in most solvents and have exceptionally good resistance to them. This is said to be particularly true of hydrocarbon solvents. The resins show negligible swelling or other changes in aliphatic and aromatic hydrocarbons.

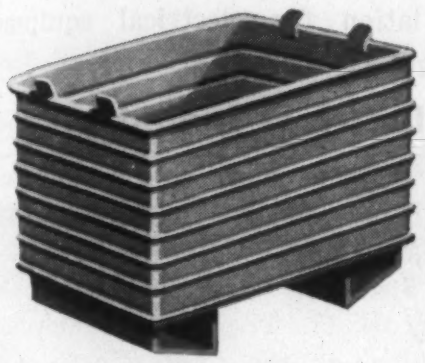
Mixing and blending

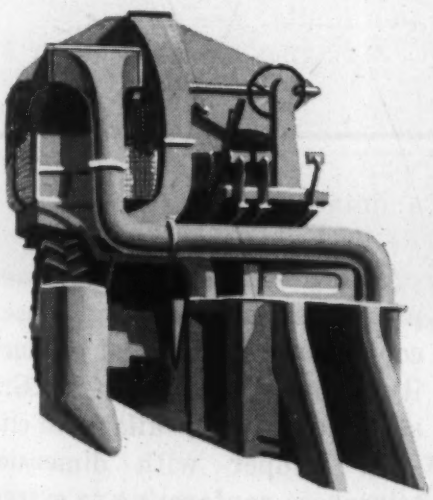
In the uncured state, Type 8 resins are soluble in alcohols and phenols. Lower alcohols are the best solvents. Normal propanol and isopropanol have good solvency, though they are somewhat inferior to methanol and ethanol in this respect. Fluid solutions of the resins can be maintained for considerable periods at room temperature. They tend to gel on prolonged storage, but gels can be liquefied again by warming.

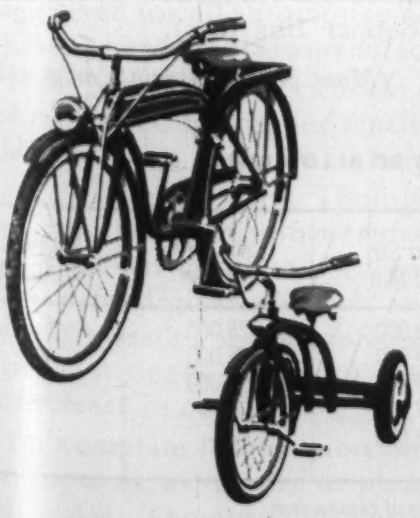
In general, the resins are compatible with highly polar compounds, though there are certain exceptions. The nitrile or buna N class of synthetic rubbers are compatible in all proportions. Other compounds compatible with Type 8 resins in certain proportions include n-butyl methacrylate, polyethylene glycol 300, chlorinated paraffin, ethyl methacrylate polymer, ethyl cellulose, nitrocellu-











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HIGH-TENSILE STEEL

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You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel —it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

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For more information, turn to Reader Service Card, Circle No. 350

lose, polyvinyl butyral, polyvinyl alcohol, glycerine, triethylene glycol urea-formaldehyde resins and some silicone resins.

Applications

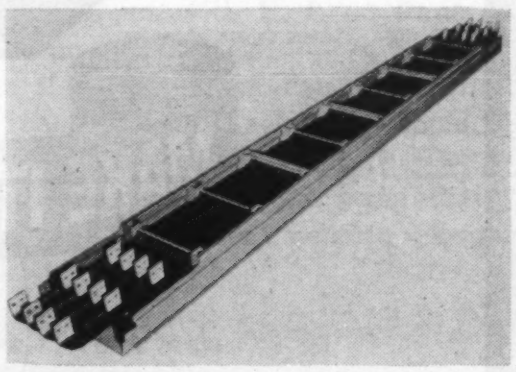
Type 8 nylon resins are being successfully used in such applications as adhesives for wood, metal, glass and glass fabrics; hydrocarbon barriers in fuel cells; coatings for paper; and in several types of finishes for textiles. Other suggested applications include gaskets and seals for hydrocarbon service; moisture-absorptive coated fabrics for sheeting and wearing apparel; abrasion resistant finishes for leather and wood; component metal finishes; and heat- and abrasion-resistant insulation for electrical equipment.

New Aluminum Alloy for Electrical Industry

Increasing use of aluminum in electrical applications has spurred the development of alloys specifically for that use (M&M, Dec. '54, p. 141). The objective is to obtain an alloy combining the light weight of aluminum with high strength and electrical conductivity. The most recent alloy to be developed is Revere Alloy 6263, marketed by *Revere Copper and Brass Inc.*, 230 Park Ave., New York 17. The alloy was developed through the joint efforts of Revere and the Aluminum Co. of Canada. The accompanying table lists guaranteed physical properties as well as chemical composition limits.

A magnesium silicide alloy, 6263 has lower electrical conductivity, but higher mechanical strength than commonly used EC grade aluminum alloy. According to Revere, close metallurgical control provides the alloy with mechanical properties approaching those of copper, with electrical conductivity approaching that of EC Grade aluminum. It is available in either —T6 temper with dimensional tolerances conforming to extruded products tolerances of the Aluminum Association; or in —T8 temper with tolerances which will meet ASTM B187 (Cold Rolled Copper Bus Bar).

(More New Materials on p. 142)



***New alloy** will be used in applications such as the bus duct assembly shown above.*

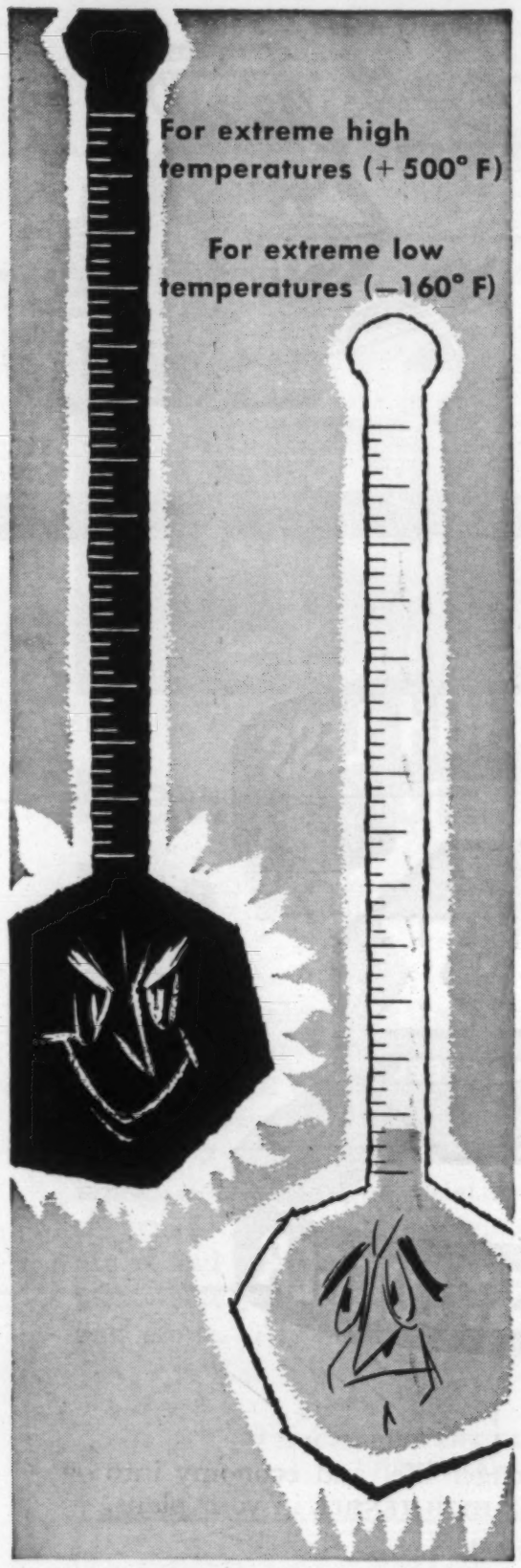
CHEMICAL COMPOSITION, %

Iron	0.40 Max
Silicon	0.30-0.60
Magnesium	0.40-0.80
Others, each	0.03 Max
Total, each	0.10 Max

TYPICAL PROPERTIES OF ALLOY 6263[1]

Alloy	Thickness, in.	Ten Str, psi Min	Yld Str, psi Min	Elect Cond % IACS Min
6263-T6	Up to 0.500	29,000	25,000	55
6263-T8	Up to 0.500	29,000	25,000	57
EC-H17[2]	Up to 0.500	17,000	15,000	61
Copper (Hard)[3]	Up to 0.375	37,500	—	97.4
Copper (Hard)[3]	0.375-0.500 incl.	33,000	—	98.4

[1] *Properties of EC-H17 and copper are given for purposes of comparison.*
[2] *ASTM B236.*
[3] *ASTM B187.*



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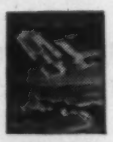
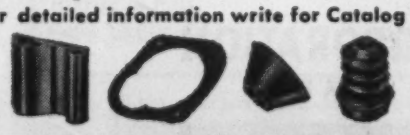


For detailed information write for Catalog 51SR-1



6307-SR

STALWART RUBBER CO.

Mfg. Plants in Bedford, Ohio and Jasper, Georgia
Main Offices 165 Northfield Road, Bedford, Ohio

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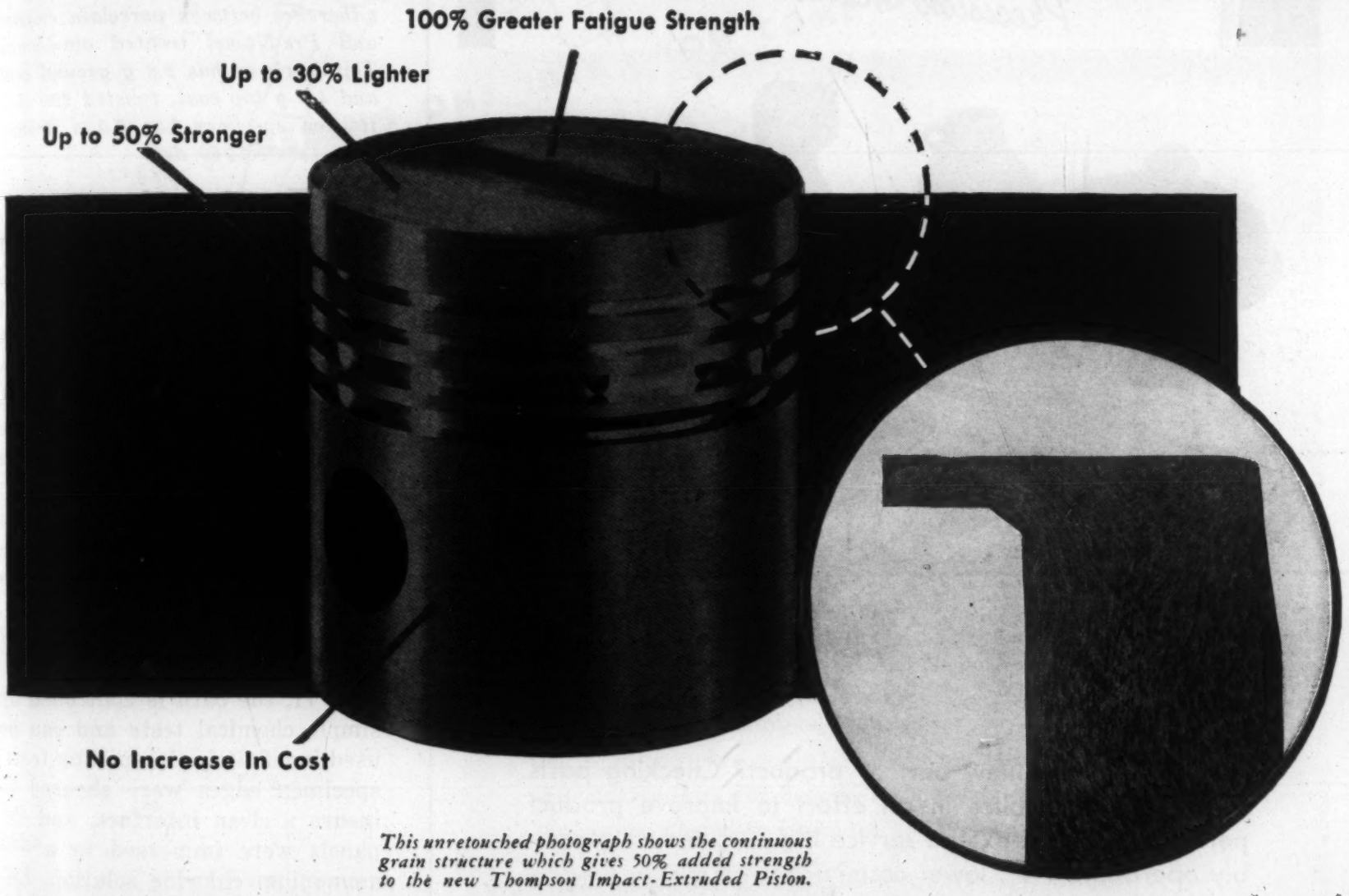
THOMPSON PRODUCTS ANNOUNCES A NEW IMPACT-EXTRUDED PISTON



This unretouched photograph shows the continuous grain structure which gives 50% added strength to the new Thompson Impact-Extruded Piston.

THE all-new Thompson Impact-Extruded Piston is the first lightweight piston especially designed and engineered for all automotive engines. This new piston will soon be available to manufacturers of piston engines.

Made by an impact-extrusion method, this new piston is heat treated for higher tensile strength, greater ductility and 100% increase in fatigue life.

For over 50 years Thompson Products has been designing and precision manufacturing automotive parts to the closest tolerances known to the industry. Constant metallurgical research and experimentation join with this design and manufacturing to bring this new, lighter, stronger piston to the automotive builder at no increase in cost.

For complete information on this newest Thompson development, write, wire or phone Light Metals Division, Dept. MM, Thompson Products, Inc., 2269 Ashland Rd., Cleveland 3, Ohio.

You can count on

Thompson Products

LIGHT METALS DIVISION
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For more information, turn to Reader Service Card, Circle No. 459

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– Reduce assembly operations
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Designing a new part or product? Checking parts in present assemblies in an effort to improve product performance . . . extend service life . . . reduce assembly operations . . . lower costs?

Call on Acushnet. We've provided the solution to troublesome production, performance and cost problems in the products of innumerable manufacturers, large and small.

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Acushnet

Acushnet Rubber Data Handbook sent when requested on your company letterhead. Also available; brochures on Rubber-To-Metal Bonding, and Silicone Rubber Parts.

ACUSHNET PROCESS COMPANY

Address all communications to 750 Belleville Ave., New Bedford, Mass.

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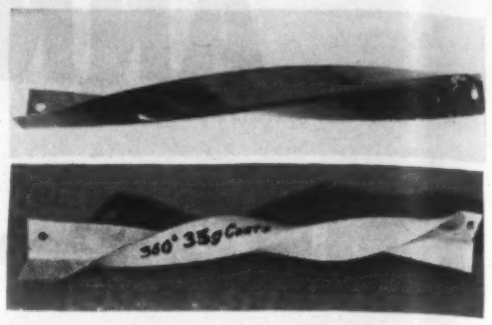
New Materials, Parts, Finishes



***Two torsion test specimens** show adherence between porcelain enamel and Pre-Namel treated aluminum. Top specimen has 2.8 g ground coat and 4.0 g top coat, twisted 220 deg. Bottom specimen has 3.5 g ground coat, twisted 360 deg.*

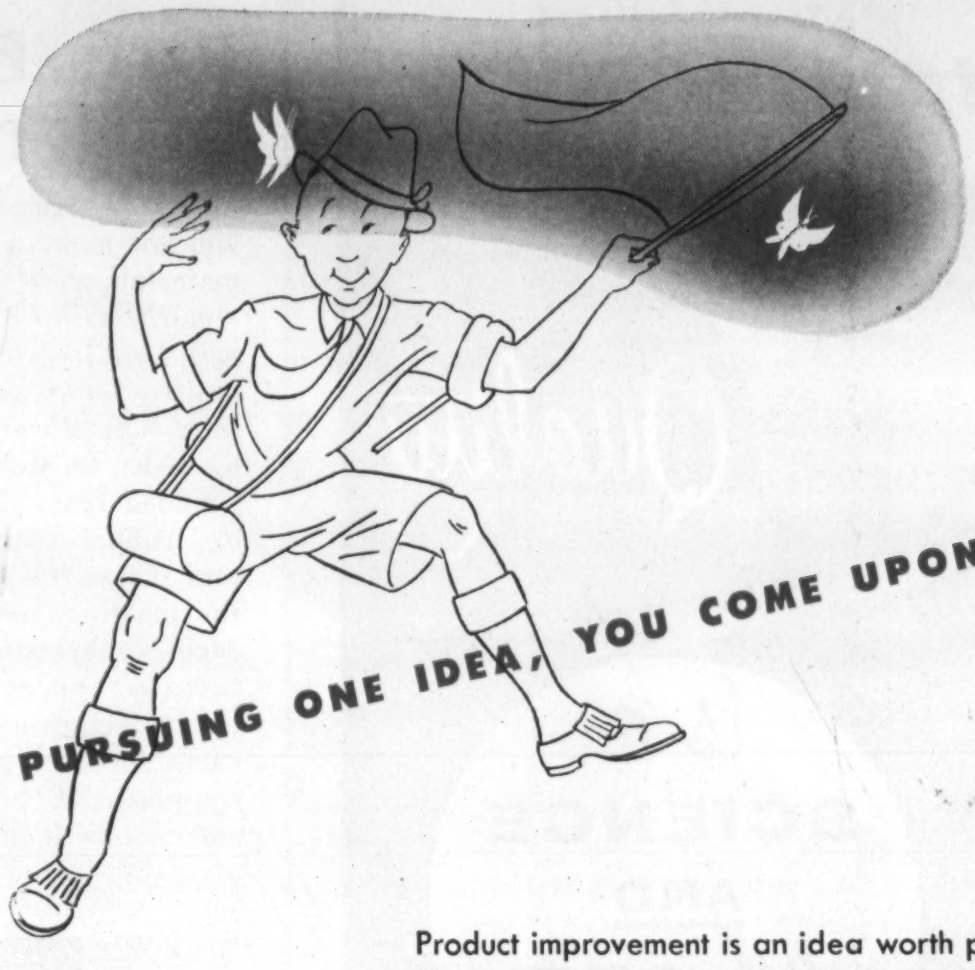
Pre-Treatment for Enameled Aluminum

A pre-treatment for aluminum has been developed which is said to assure good bond strength between the aluminum and subsequent coats of porcelain enamel. Called Parker Pre-Namel 420, the material is dipped or sprayed on aluminum and dried, resulting in a thin, iridescent coating which is integral with the metal and provides a good base for porcelain enamel. No pre-firing is necessary. Developed by *Parker Rust Proof Co.*, 2177 E. Milwaukee Ave., Detroit 11, the bath is controlled by simple chemical tests and can be used indefinitely. In spalling tests, specimen edges were sheared to insure a clean interface, and the panels were immersed in a 5% ammonium chloride solution. Enamel loss along edges after 96 hr was said to be nil.

Silicone Rubber Flexible at 600 F

Though silicone rubber has been hitherto limited to a maximum usable temperature of about 500 F, new silicone rubber materials have been developed which remain flexible for 150 hr or longer at temperatures up to 600 F. This improved high temperature resistance of Class 700 materials is said to have been gained without sacrifice of other properties of silicone rubber such as ozone, aging and weather resist-

FAMOUS FOR QUOTATIONS



"IN PURSUING ONE IDEA, YOU COME UPON ANOTHER"

— Cecil Rhodes

Product improvement is an idea worth pursuing, and a fine idea for achieving it is through the use of Wolverine extruded aluminum shapes.

Wolverine's years of metalworking experience—careful inspection of the most minute details—insure tolerances that meet tough specifications and finishes that are satin smooth. Strong, lightweight Wolverine aluminum extrusions contribute to improved design, permit substantial savings in both materials and production time—are available in popular alloys.

If you now use—or are contemplating the use of extruded aluminum shapes—remember that Wolverine, too, is famous for quotations. *Get ours before placing your next order.* For helpful information write for the Wolverine Aluminum Catalog. You'll get one—*pronto!*

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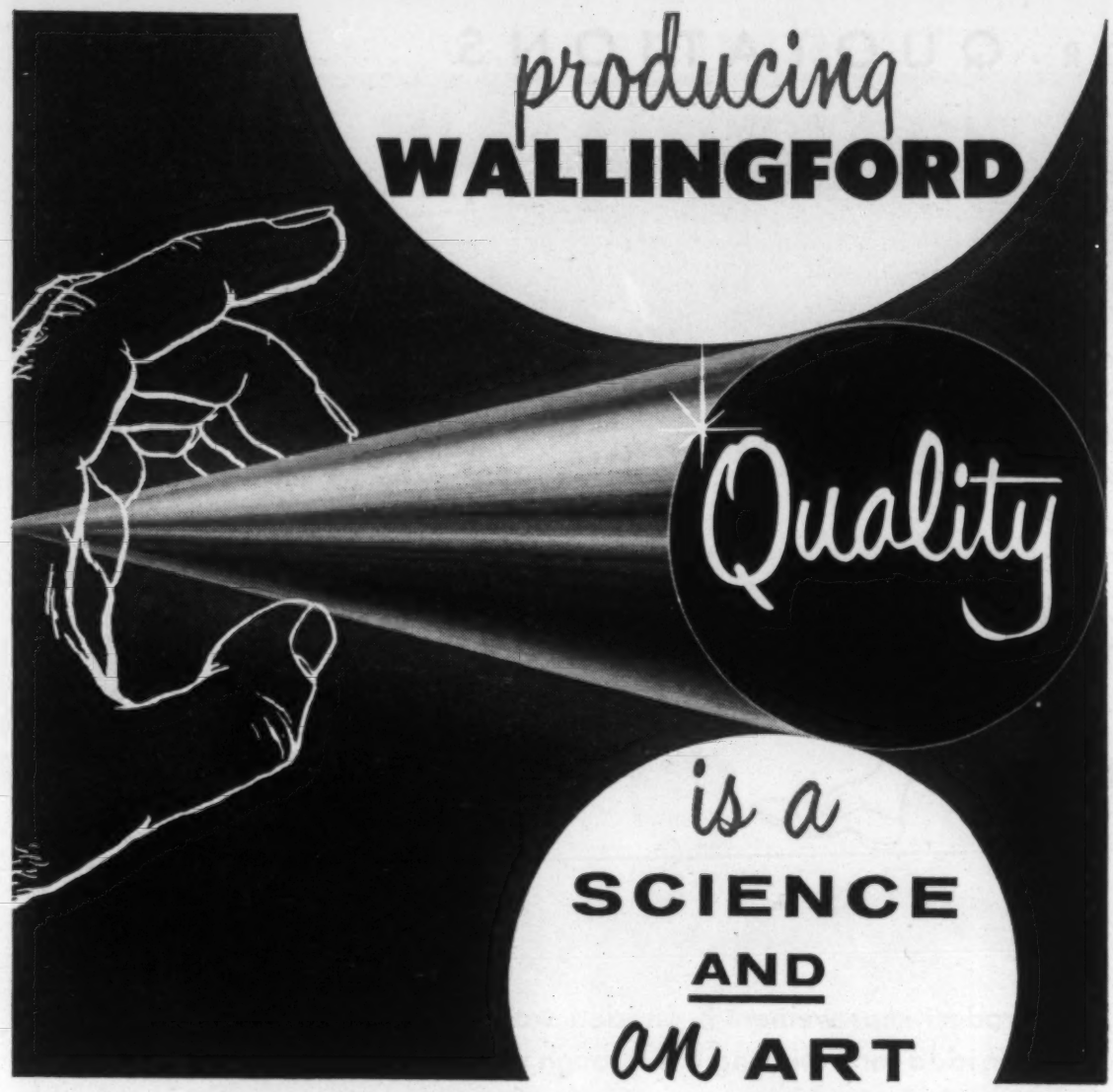

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Producing stainless steel tubes and pipe of the highest uniform quality takes the finest modern equipment. And, at Wallingford, whenever there is a better machine or a more advanced quality control device, it is obtained and integrated into our manufacturing operations.

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Welded Ornamental, Mechanical, Pressure; Sanitary, Aircraft and Shaped Tubing and Pipe from ⅜" to 3" OD

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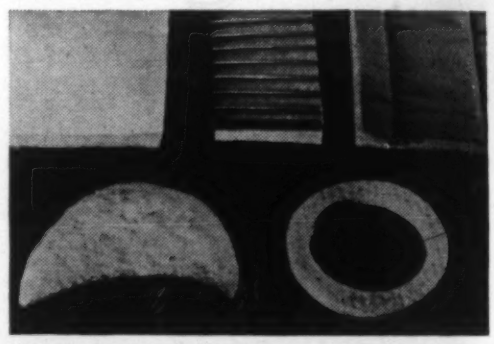
For more information, turn to Reader Service Card, Circle No. 347

New Materials, Parts, Finishes

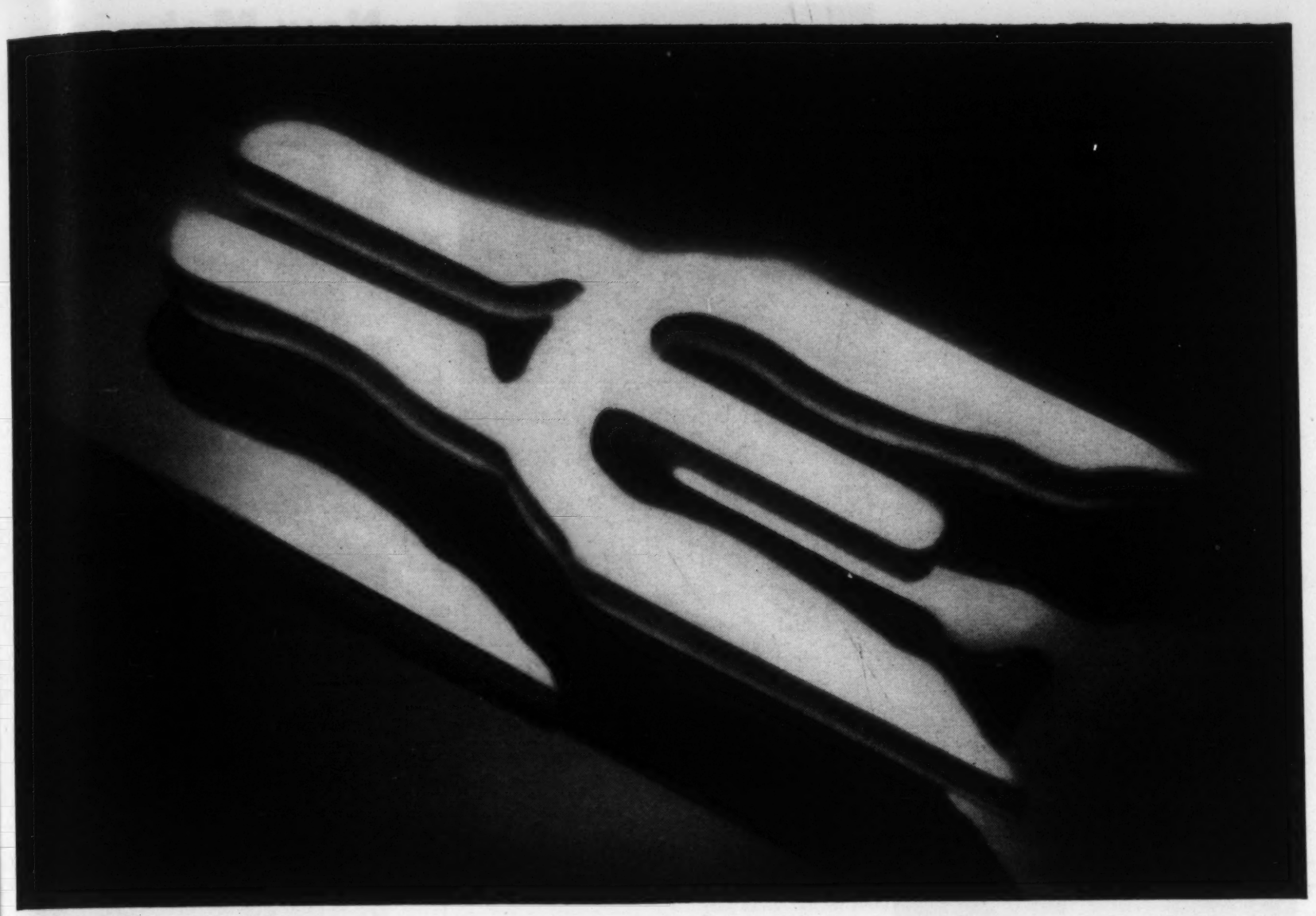
ance, low temperature flexibility and low moisture absorption. The materials were developed by *General Electric Co.'s Silicone Products Dept.*, Waterford, N. Y. The designation, Class 700, covers silicone rubber compounds produced by G-E, as well as stocks compounded from G-E silicone gums by rubber compounder-fabricators. Class 700 stocks are suitable for molding, extrusion or calendering fabrication methods. Anticipated applications for the materials include oven door seals and parts for hot materials handling equipment in the glass, ceramics and metals industry.



Nylon and Phenolic in Padding Material

A highly resilient padding material composed of nylon fibers bonded with phenolic resins has been developed. Though more expensive than conventional types of padding, Nylabond's durability and versatility are said to make it economical for many uses. It is light weight, has high tensile, shear and impact strengths and will withstand dry heat or steam up to 350 F for short periods, and up to 250 F for long periods. Using Bakelite's phenolic resins, the material was developed by *Gustin-Bacon Mfg. Co.*, 210 W. 10th St., Kansas City 6, Mo.

Produced in densities ranging from 1 to 6 lb per cu ft and in thicknesses from ¼ to 2 in., Nylabond is said to be resistant to cold, mold, fungus and bacterial growth. It can be attached to other fabrics using adhesive, heat-sealing or stitching methods, and

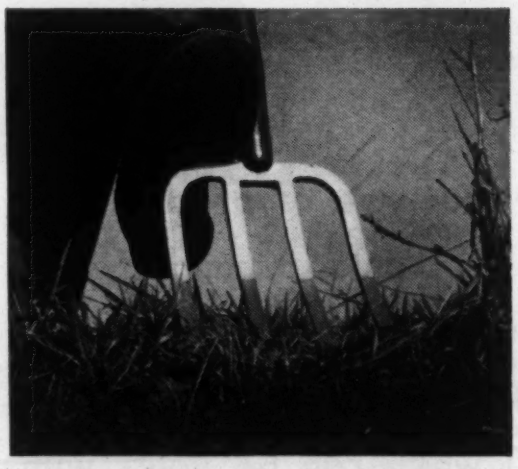


Making a carbon-steel bar into a heavy-duty garden tool

It's an ingenious process, transforming a flat carbon-steel bar into the complex head of a spading fork.

The Union Fork & Hoe people, who produce a highly popular line of garden tools, start with 14-ft lengths of 4¼-in. x ½-in. bars of C-1095 steel, which Bethlehem supplies to them in substantial quantities for this application.

After the bar has been thoroughly pre-heated, a rough pattern is press-forged—that's the unique five-fingered forging you see above. The four large "fingers" are formed into the diamond back tines by passing them through grooved rolls a *minimum* of forty times. Then the head is reheated and pressed into its final shape, which requires that the two outer tines be turned 180 deg. Next,



the tines are trimmed and pointed, and the head is made concave.

Carefully regulated heat-treatment follows. Naturally, this step is extremely important, because it adds the toughness and flexibility so vital in a spading fork.

The finishing operations include shot-peening, which imparts added surface hardness; polishing for good appearance; and coating with anti-rust compound. Fitted with a strong white-ash handle, the fork is ready to give yeoman service.

Does your product require good, sound carbon-bar stock? Try Bethlehem! We can fill your requirements for hot-rolled carbon-steel bars in standard or special sections, and bar-size shapes. Also semi-finished carbon-steel products: blooms, billets and slabs. For further information, please get in touch with the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service Card, Circle No. 394

"One day we were using 14 hand sprayers ...the next day, 2

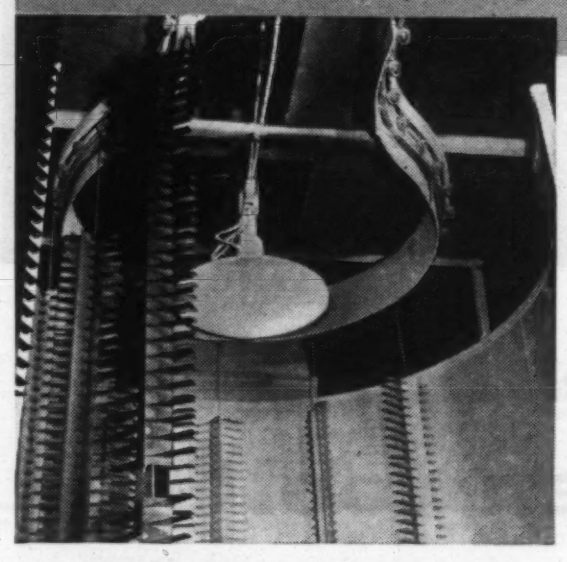
"One day we were using 180 gallons of paint ...the next day, 75

"Fantastic?" Not exactly. It's a typical, on-the-job-example of the savings made possible with the

RANSBURG NO. 2 PROCESS

Electrostatic Spray Painting

And, in this instance* production was increased; quality of the work improved, and rejections cut to practically nothing.



*Fluorescent Fixtures of California, in their modern plant in South San Francisco, uses the Ransburg No. 2 Process Reciprocating Disc Atomizer to paint their popular line of ALL-BRITE lighting fixtures. The quotes above are from Works Manager, R. H. Shaffer.

Regardless of the type of product you manufacture, if it's painted... and, if your production justifies conveyorized painting, you should look into the savings (and improved quality) which can be yours with one of the Ransburg Electrostatic Painting Processes. May we tell you about complete Ransburg services?

Write Dept. M

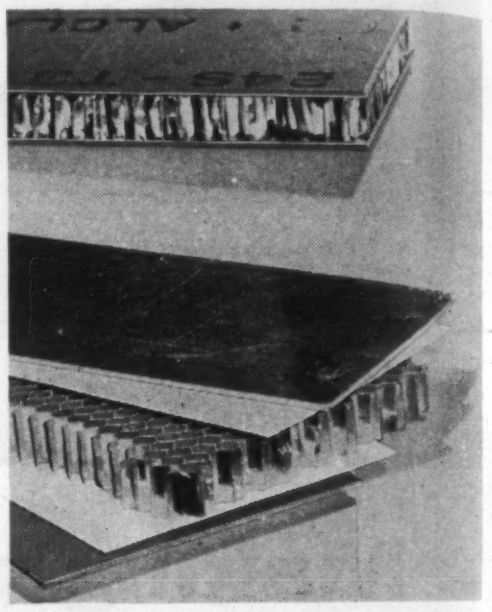
Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

For more information, turn to Reader Service Card, Circle No. 328

New Materials, Parts, Finishes

can be post-formed through use of heat and pressure. Open structure of fibers permits the padding to breathe. The pad does not wick water, but holds it with a sponge-like action. It is recommended for automotive interiors, garment pads, lubricating gaskets, and as an effective thermal insulating material.

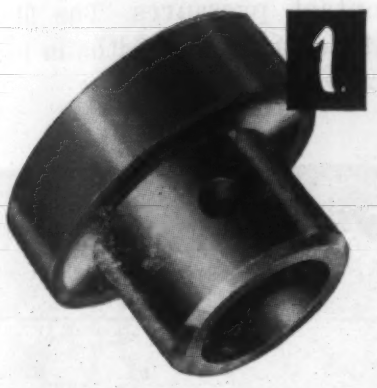


New Adhesive in Film Form

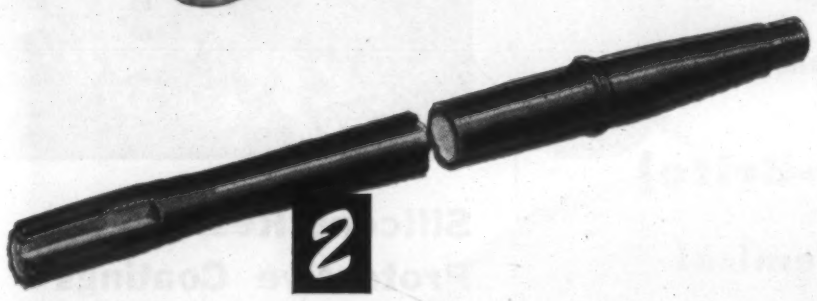
A new adhesive film supported on a glass renforcing mat has been developed for bonding metal either to metal or to rigid plastics. Peel strengths of resultant bonds are said to range up to 40 lb per in. with a 2000 psi tensile shear. Developed by *Rubber & Asbestos Corp.*, 225 Belleville Ave., Bloomfield, N. J., Plymaster V-2 is approximately 11 mils thick, though glue lines of 1½ mils can be obtained by applying pressure when making the bond. The film form of the adhesive is said to provide speed, efficiency and economy in joining a variety of materials such as metal-to-metal; vinyl sheet-to-steel; reinforced plastics laminates-to-aluminum; rigid phenolic or polyester sheet-to-metals, etc.

While maximum physicals invove a curing cycle of 300 F for 10 min with a pressure of about 50 psi, variations in time down to 5 min or less, and in pressure

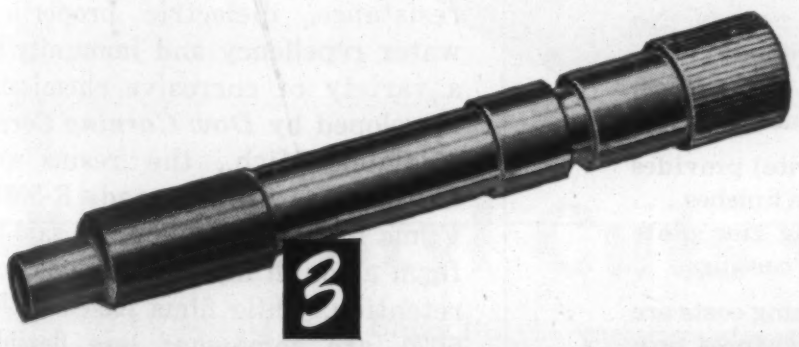
7 WAYS to SAVE MONEY with TOCCO* Induction Hardening



Cost was reduced 94% when heat-treatment of this corn-harvester part was changed from carburizing to TOCCO-hardening, 9½c saved on every piece — $4750 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour.

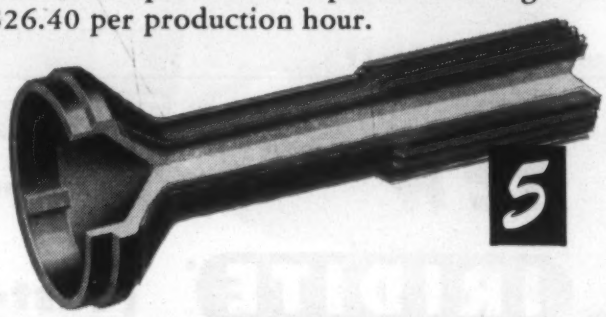


Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of $375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.



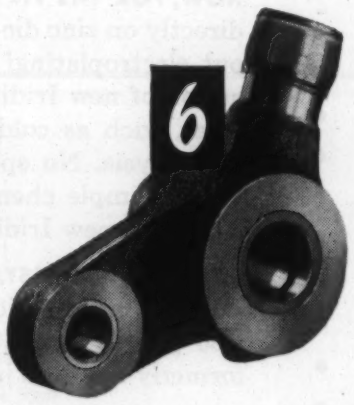
Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from $1.57 to 10c apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11c per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.

Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from $5.45 to $3.25 per hundred parts—a savings of 2c per pin, $26.40 per production hour.



Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4c per piece—$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.



7 Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for similar cost-saving results—without obligation, of course.

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you can get this brilliant finish directly on zinc die castings!

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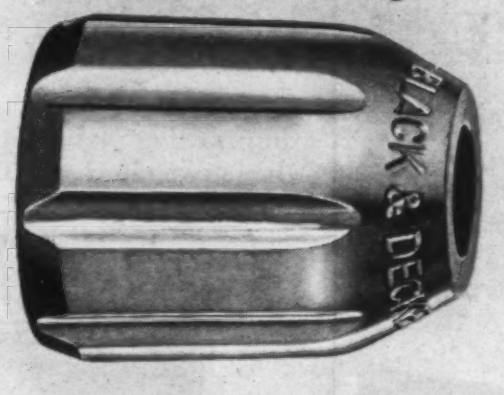
No electroplating--no mechanical finishing!



TREATED WITH NEW IRIDITE

NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. *IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.*

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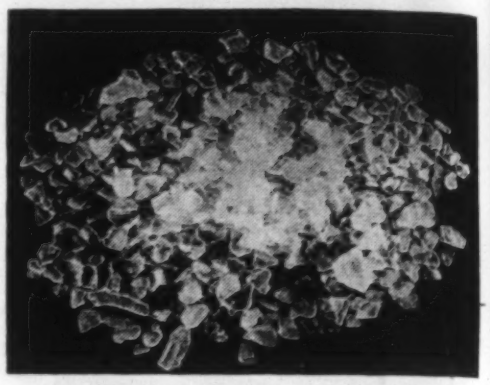
New Materials, Parts, Finishes

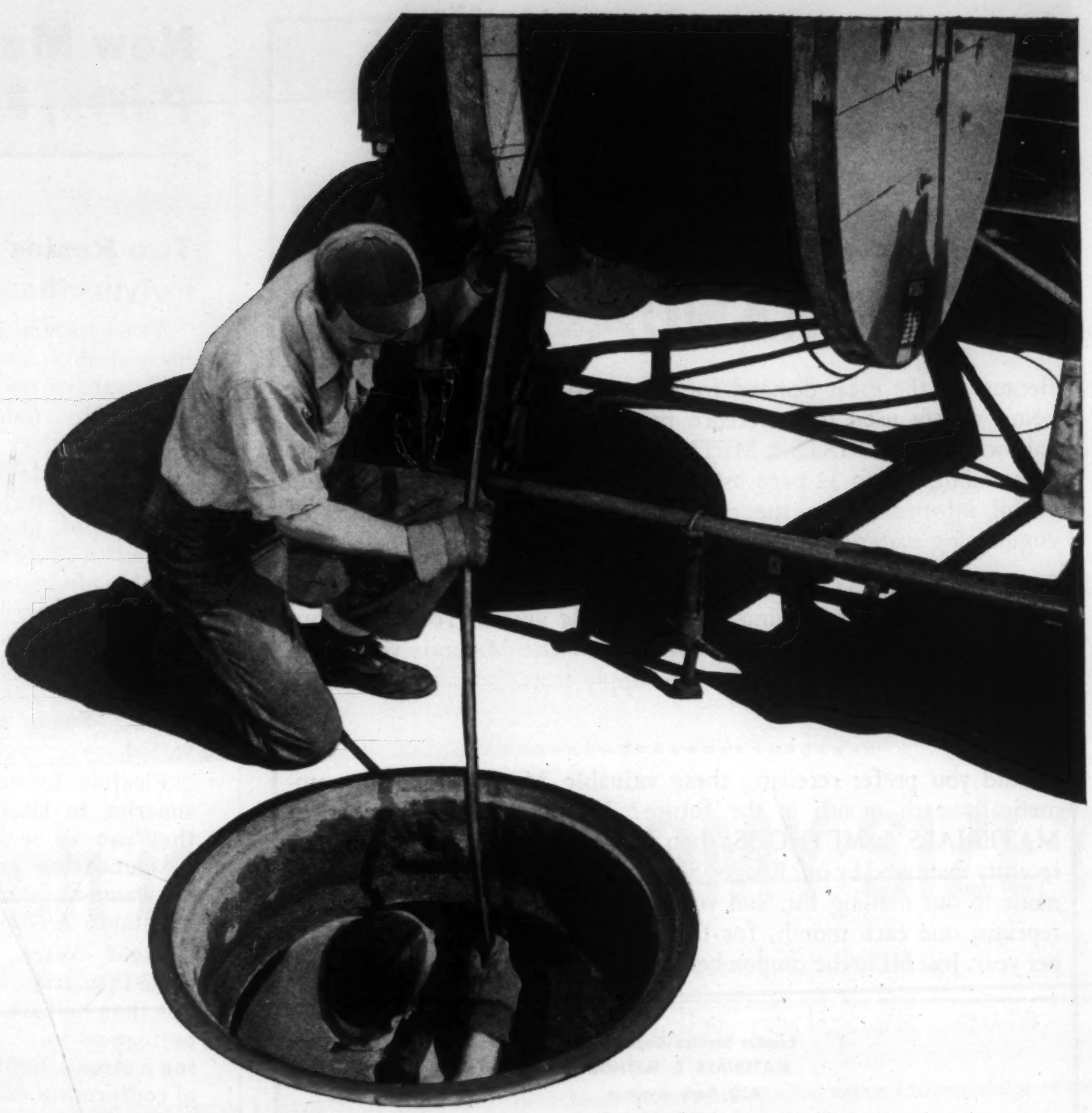
down to 10 to 12 psi can be used. Adhesive flow is obtained in the vicinity of 200 F. Where desirable, the film may also be solvent or adhesive primer reactivated to yield bonds at room temperature and contact pressures. The film is availabe in 36 in. widths in 100 yd rolls.



Silicone Resins for Protective Coatings

Two 100% silicone resins have been marketed for formulating silicone-based protective coatings. Properly applied and cured, films based on the resins have good heat resistance, dielectric properties, water repellency and immunity to a variety of corrosive chemicals. Developed by *Dow Corning Corp.*, Midland, Mich., the resins are designated R-5061 and R-5071. Films based on R-5061 are said to form a tough film with good color retention, while films based on R-5071 are somewhat less flexible and more thermosetting. Intermediate physical properties may be obtained by blending the resins in any desired proportions. Both resins are available as crumbled solids which are soluble in a range of solvents and compatible with many heat-stable fillers and pigments. They are adaptable to formulations requiring uncommon solvents or unusually high solids ratios. The resins are well suited for preparation of silk screen enamels or other specialized coatings. Currently available in commercial quantities, both resins are priced in the range of $5.00 per lb.

(More New Materials on p. 150)



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The rapidly expanding use of Enjay Butyl in underground cable insulation is still another example of how it cuts costs . . . *and* does a better job.

Enjay Butyl high voltage compounds have extraordinary resistance to ozone and corona. They show high insulation resistance, are very stable to temperature change, and have power factor and dielectric properties which are superior to other insulation materials. Exceptional low-temperature flexibility, excellent resistance to heat and aging, and resistance to moisture absorption and abrasion are still further benefits.

Enjay Butyl offers three outstanding features: *excellent electrical* properties, a *definite price advantage*, and *immediate availability*. They may well help *you* in cutting costs and increasing the performance of your product. Get all the data on this extremely versatile, low cost rubber by contacting the Enjay Company today. Take advantage of our complete laboratory facilities and skilled technical assistance.

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New Materials, Parts, Finishes

Two Resins for Polyurethane Foams

Two experimental polyester resins suitable for use in making polyurethane foams have been developed by *Reichold Chemicals, Inc., Polyester Resin Div.*, 525 N. Broadway, White Plains, N. Y. The resins are available in developmental quantities. Polyurethane is a rubber-like plastics material made by mixing a polyester with toluene diisocyanate and various additives. One of the new polyesters is suitable for making flexible foams, the other for rigid foams. Foam density can be varied.

Flexible foams are said to be superior to latex rubber in that they can be sewn, stand up well to laundering and dry cleaning, are flame-resistant, and have high resistance to ozone and sunlight.

Rigid foams have about the same insulation value as cork, but less than half its weight. They can be foamed in place quickly, creating a strong, light block of material conforming exactly to a desired shape.

New Cement Bonds Rubber

A cover-cement designed for vulcanized bonding of butyl compounds to metals and as a one-coat adhesive for vulcanized bonding of butyl compounds to each other and to other types of rubbers has been developed by *Marbon Chemical, Div. of Borg-Warner Corp.*, Gary, Ind. Called Ty-Ply BC, the material is a black liquid containing 17% dispersed solids. It is supplied at brushing viscosity and will provide coverage of 600 sq ft per gal. It dries at room temperature in 30 min. For spray and dip operations, thinning is recommended.

For bonding butyl rubbers to ferrous metals, Ty-Ply BC is used as a cover-cement over Ty-Ply UP

Which is the ECONOMY SIZE?

3 times stronger than carbon steel, Lukens "T-1" steel slashes equipment weight, reduces costs

The lighter weight, reduced thickness of Lukens "T-1" steel, in comparison to heavier, thicker plates of ordinary carbon steel, makes possible substantial over-all savings in material, fabrication, construction and maintenance. Where designers and engineers can take full advantage of it, this unique, low-carbon, quenched and tempered alloy plate steel offers many superior properties. With a yield strength three times greater than ordinary carbon steel, Lukens "T-1" steel can cut costs by reducing weight and still allow increased payloads and efficiency.

Equipment fabrication is no problem with Lukens "T-1" steel. It is readily welded without preheating or stress relieving; equipment can easily be fabricated, modified or repaired at the field site. Its exceptional toughness and resistance to wear and impact lowers maintenance costs and lengthens equipment life. Additional savings are possible where Lukens' range of steel plate sizes—including the widest and heaviest available anywhere—make possible the use of wider sizes that require fewer welded seams.

Lukens "T-1" steel is the most recent addition to Lukens' complete line of carbon, alloy and clad steels. Its unusual combination of properties suit it especially to application in pressure vessels, bridges, shipbuilding, construction machinery and general industrial equipment. On problems of design, selection, application and fabricating techniques, Lukens offers full technical assistance. If you would like further information on Lukens "T-1" steel, write for Bulletin 765 on its properties, characteristics and applications. Address: Manager, Marketing Service, 776 Lukens Bldg., Lukens Steel Co., Coatesville, Pa.

LUKENS **"T-1" STEEL** THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS

LUKENS STEEL COMPANY, COATESVILLE, PA.

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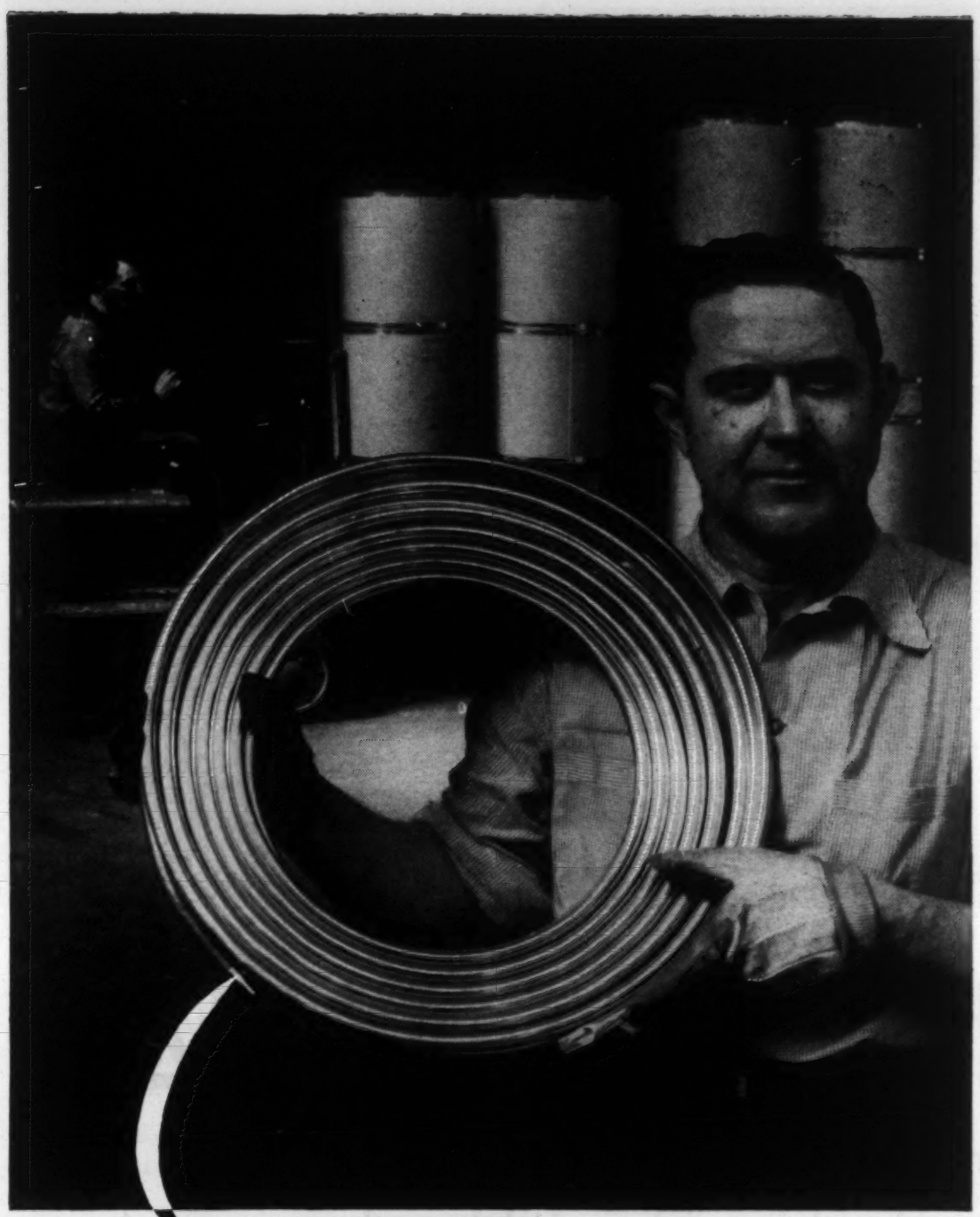

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New Materials, Parts, Finishes

primer. This two-coat system provides bond strengths, depending on the compounds used, of around 30 to 120 lb per in. strip tensile on degreased and vapor blasted steel surfaces. The system when used for bonding butyl compounds to nonferrous metals should give approximately the same results as Ty-Ply UP-RC systems, according to the company.

The BC cement, used alone, is said to provide effective vulcanized bonds between cured and uncured butyl compounds and between butyl compounds and typical compounds of GR-S neoprene, natural rubber and buna N. It is not recommended for bonding unvulcanized butyl to vulcanized natural rubber, neoprene or buna N. According to Marbon, good heat stability of the material indicates the feasibility of hot application for rapid drying. Storing the adhesive for 1 mo at temperatures ranging from 20 to 120 F shows no adverse effects on the cement, application properties or resultant adhesion.

Plastisol Coating Resists Chemicals

A new chemical-resistant plastisol has been marketed which is said to provide a smooth, dense, tough, abrasion resistant and resilient film. Supplied as a free-flowing liquid it is converted by heat into a flexible rubber-like protective coating for metal parts. Primarily intended for cold or hot dipping applications, the plastisol was developed by *Watson-Standard Co.*, 217 Galveston Ave., Pittsburgh 12, and designated #16-093.

Coatings may vary from 1/32 to ½ in. and properly cured are said to have a tensile strength of 1800 psi, a durometer Shore A hardness of 60-65 and a specific gravity of 1.20 to 1.25. Coatings are said to have high resistance to oils, greases, acids, alkalies, salts

For more information, Circle No. 472

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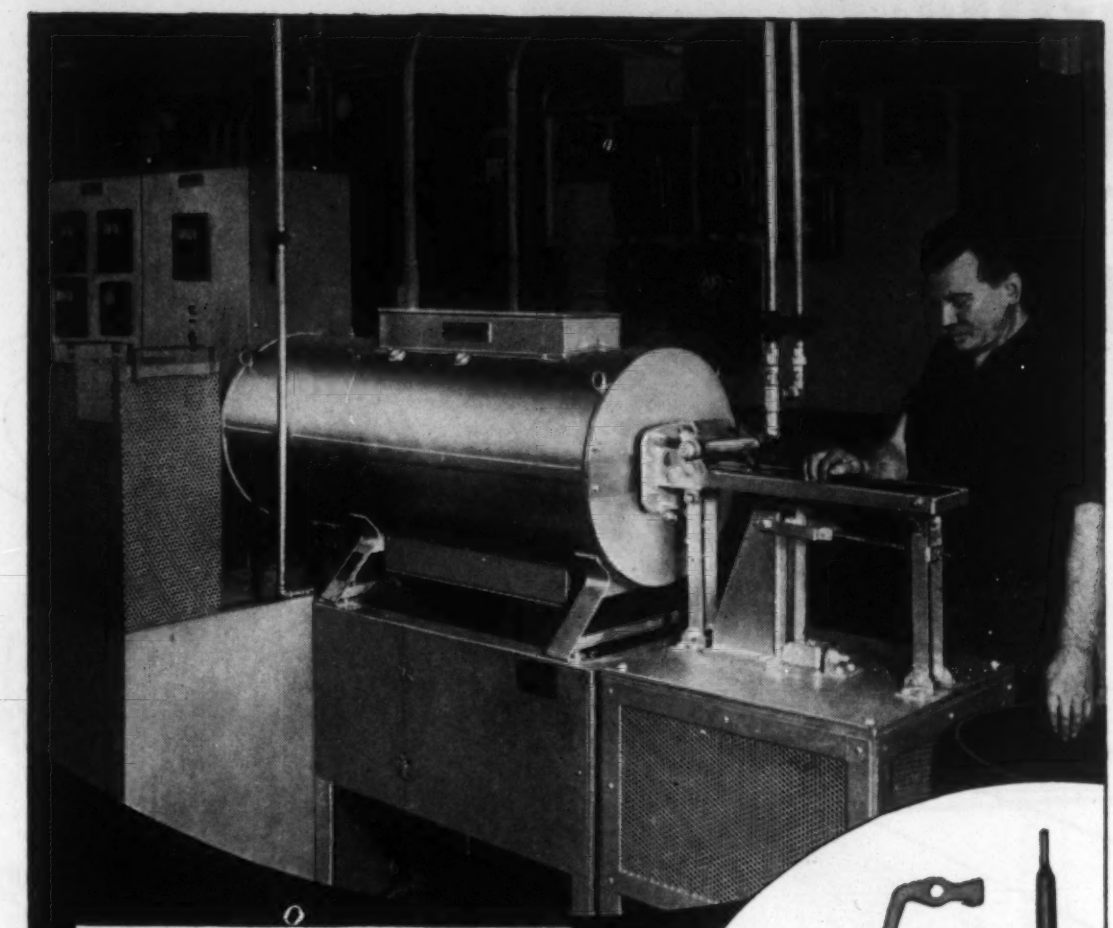

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Shaker Hearth FURNACES

This furnace used to Carburize, Dry Cyanide or Bright Harden these parts.

Save Time . . .

Money . . . Material!

Check these operations:

- Hardening small lock spring formerly took two days, now only 75 minutes. Rejects were 30%, now less than 1%.
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- Stainless steel springs "Bright" hardened without distortion because the parts are individually heated in a protective atmosphere and then are dropped directly into the oil quench.

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Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

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New Materials, Parts, Finishes

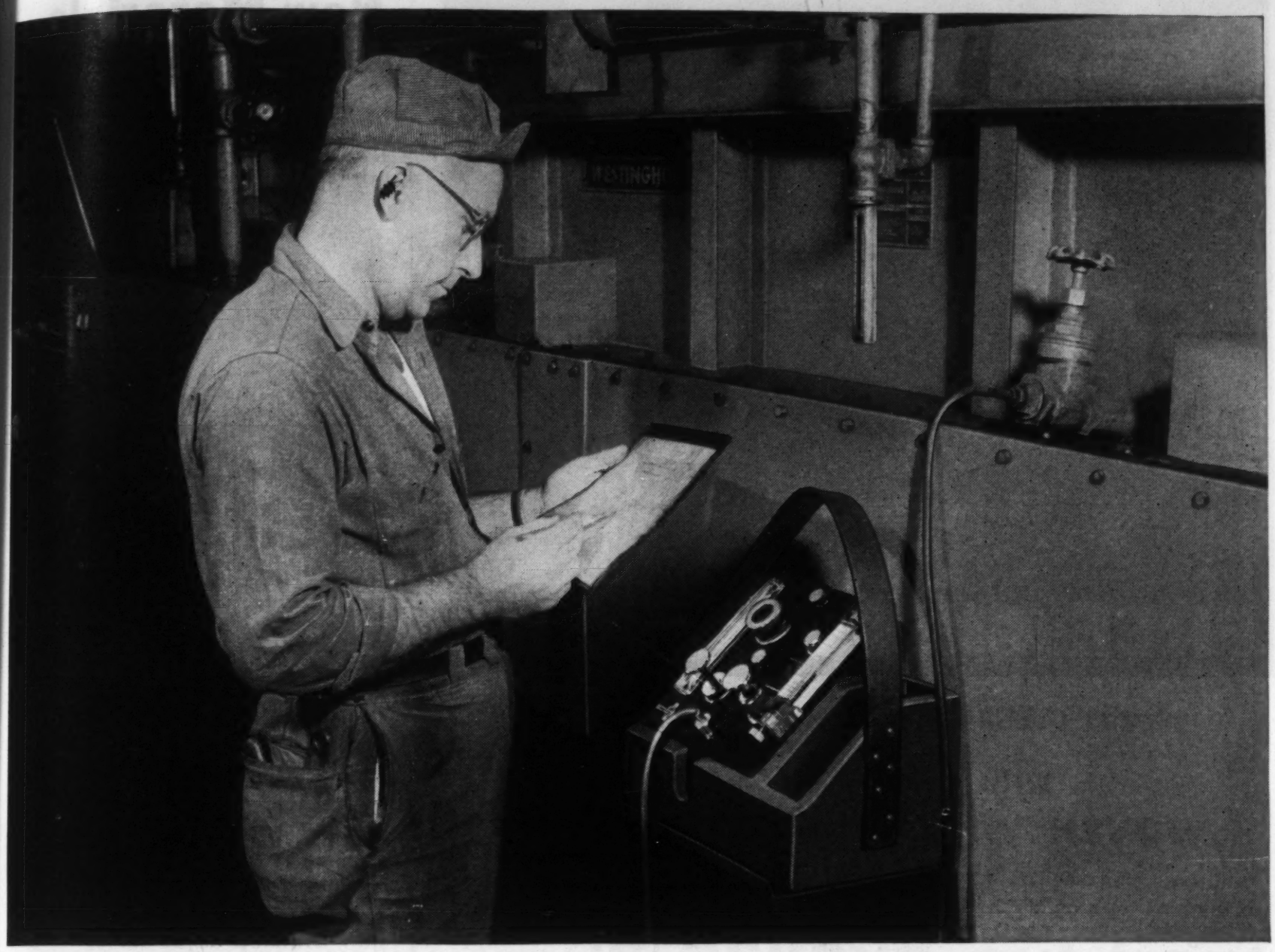
of organic acids and petroleum solvents. The material is black, though other colors can be supplied on request. It may be modified for spray or roller application. It is said to be well suited for use on racks, tote baskets, tank linings, valve parts, shelving and other metallic surfaces where chemical resistance is required.

New Electrical Joint Compound

A new compound for sealing electrical connections serves both as a sealing agent and as a solvent to remove oxide films from aluminum conductors. Developed by *Aluminum Co. of America*, Alcoa Bldg., Pittsburgh 19, No. 2 Electrical Joint Compound is a grease-type compound which is insoluble in water, has a flow point of approximately 150 F and has no tendency to harden other than through natural aging. Tests indicate the film will remain in a joint at temperatures up to 200 F. It is said to dissolve or disperse thin aluminum oxide films without attacking the base aluminum. It also prevents re-formation of oxide films within normal conductor temperature ranges. Joints made with the compound are in the same low resistance range as silver-plated joints. Although the compound was developed for bolted bus joints, tests indicate that it is also applicable for bolted electrical connections where cable is used as the conductor.

Teflon Felts for Industrial Filters

Non-woven felts made of Teflon fiber, DuPont's tetrafluoroethylene plastics, are being produced in pilot plant quantities by *E. I. du Pont de Nemours & Co.*, Wilmington, Del. Teflon felt can withstand temperatures up to 400 F almost



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"The most valuable information for the heat treater... is accurate, reliable data to show him how to adjust furnace atmosphere."

That is one of the most significant quotes from papers presented at the recent National Metal Congress. And the practical answer on control of furnace atmospheres is to determine carbon potential by reading dewpoints in each furnace zone with an Alnor Dewpointer.

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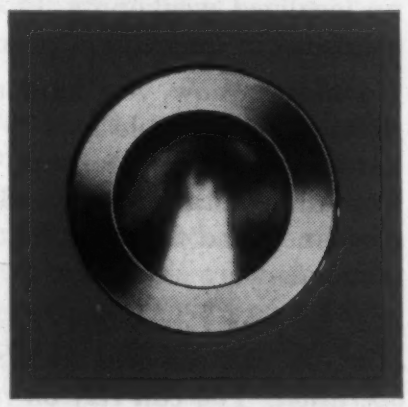
1. Read Each Furnace Zone. With the portable, self-contained Dewpointer, you can readily check each zone in the furnace...instantly detect restricted flow of atmosphere, leaky furnace seals or transient moisture and air from the quench tank, and air carried into the furnace with the charge.

2. Get Accurate Data. Only the Dewpointer gives you controlled testing conditions...indications take place in enclosed chamber. Dew or fog is suspended in air as sunbeams—not on a polished surface. This gives you the greater accuracy, faster readings required for critical atmosphere control.

3. Fast, Easy Reading. In one relatively inexpensive instrument, the Dewpointer brings you simple, direct operation that enables any shop man to get readings with laboratory accuracy—every time. It is wholly self-contained, operates on either AC or enclosed battery.



Eliminate Guesswork

You actually see the dew or fog suspended in a test chamber—no guessing as to when fog starts to form on polished surface. Find out why the Dewpointer is so widely used for accurate atmosphere control. Send for your copy of new illustrated Dewpointer Bulletin.

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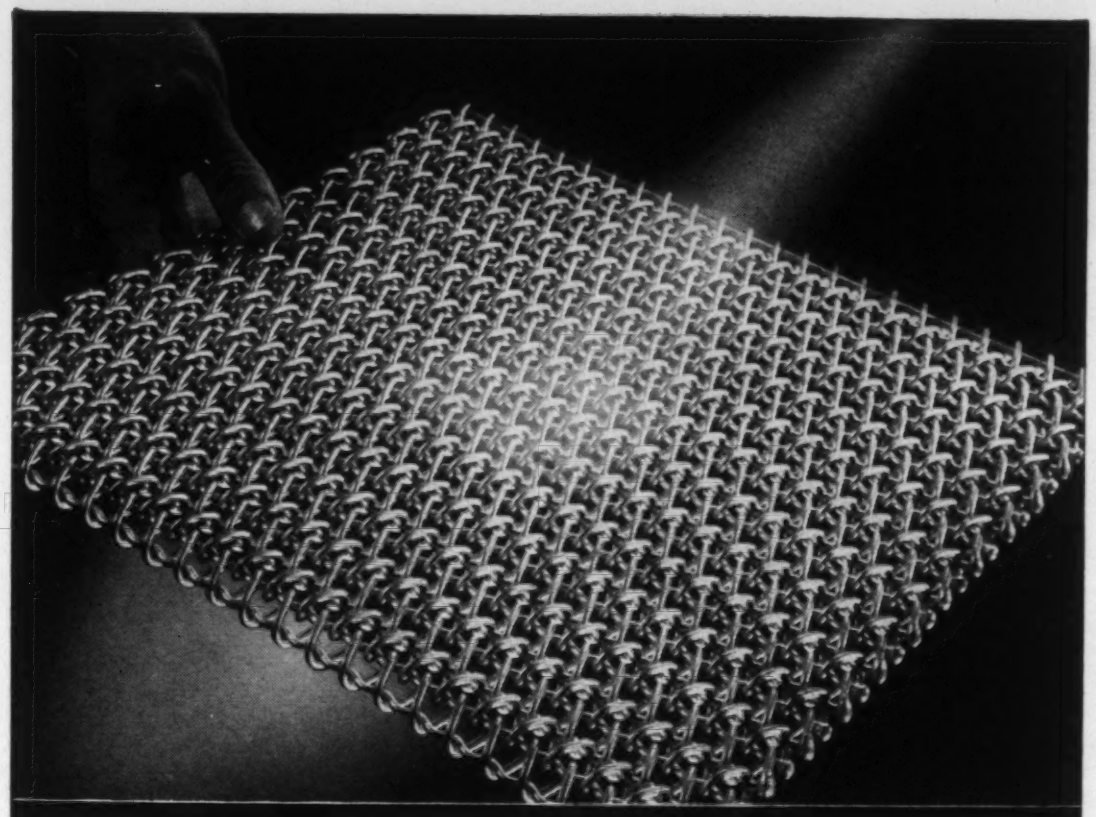

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All-metal Cambridge Woven Wire Conveyor Belts are impervious to damage from constant operation at temperatures up to 2100° F . . . have no seams, lacers or fasteners to wear more rapidly than the body of the belt, no localized weakening. Open mesh also permits free drainage of process solutions in quenching, pickling and tempering.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . eliminate profit-stealing batch and hand operations. They are made in any size, mesh or weave, and from any metal or alloy. Special raised edges or cross-mounted flights to hold your product during movement are available.

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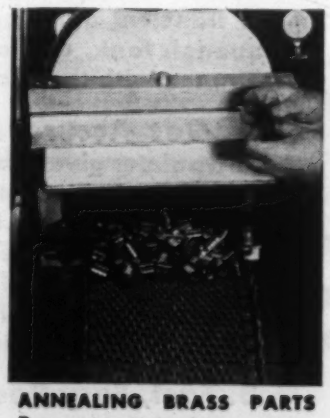
WRITE TODAY FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.



ANNEALING BRASS PARTS Process atmosphere circulates freely through open mesh of Cambridge belt and around small or large parts.

The Cambridge Wire Cloth Company

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Cambridge 8,
Maryland

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For more information, turn to Reader Service Card, Circle No. 339

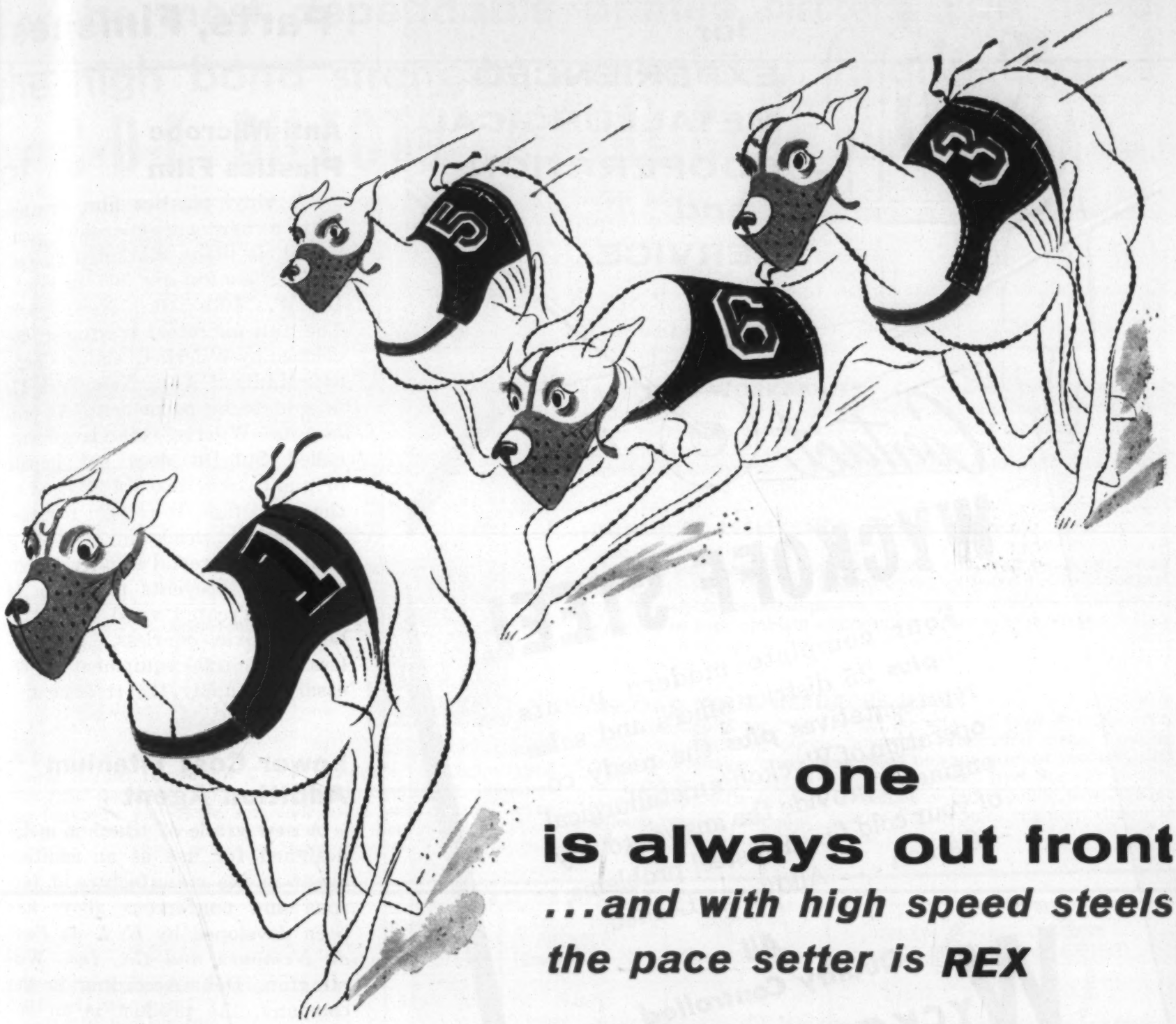
New Materials, Parts, Finishes

indefinitely and is highly resistant to chemicals. It can be boiled in aqua regia or fuming sulfuric acid with no adverse effect. Virtually nothing can stick to the material nor does it absorb moisture. The material is well suited for applications where heat and corrosive chemicals present problems. It is also being used to improve efficiency of equipment designed to remove water vapor from air going to compressors. Maximum size now available is 20 in. by 40 yd in thicknesses from 1/16 to ½ in. Price at present is $42 per lb.

New Aluminum Tubing Has High Strength

New high-strength aluminum specialty tubing made of 6066 alloy is now being produced in round, square, rectangular and special configurations by *Harvey Aluminum*, 19200 S. Western Ave, Torrance, Calif. In addition to high strength characteristics, the 6066 tubing is said to be highly resistant to general corrosive conditions and have good weldability and surface finish. It is available in a range of sizes. The tubing is recommended for use in water heaters, gas engines, refrigerators, appliances, condensers, unit heaters, air lines pumps and water lines. Structural applications include scaffolds, rails, booms, mullions, and transmission towers.

(More New Materials on p. 158)



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Crucible's REX high speed steels have been way out in front ever since their introduction. And today they're still the *standard for comparison* wherever high speed steels are used.

There are many good reasons for REX's leadership — uniformity of size, structure, finish, response to heat treatment, tool performance. Each factor can be proved in your own shop, on your own work. So try this *standard for comparison* on a few jobs and you'll agree with thousands of users — *you can't find a high speed steel to outperform REX.*

Because of its extensive, nationwide use, REX high speed steel is carried in stock by the coast-to-coast chain of Crucible warehouses, or is available on quick mill delivery. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

Visit us at Booths 830-832 Production Engineering Show, September 6-16, Navy Pier, Chicago.

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

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and
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WYCKOFF STEEL PRODUCTS — Carbon and Alloy Steels • Turned and
Polished Shafting • Turned and Ground Shafting • Wide Flats up to 12" x 2"
All types of furnace treated Steels

For more information, turn to Reader Service Card, Circle No. 326

New Materials, Parts, Finishes

Anti-Microbe Plastics Film

A vinyl plastics film, treated with a new anti-microbial compound, is being marketed by *Imperial Chemical and Plastic Corp.*, 16 W. 40th St., New York. The anti-microbial treatment, developed by Wilcris Chemical Corp., 342 Madison Ave., New York 17, is said to be permanent. According to Wilcris, the treatment, called Sub-Du does not impair original color, texture or hand of the vinyl film. It is said to function as a deodorant, since it strikes at bacterial activity. Treatment also prevents formation of mildew. Treated vinyl is said to be non-toxic, odorless, and colorless. No special equipment is necessary to apply the treatment.

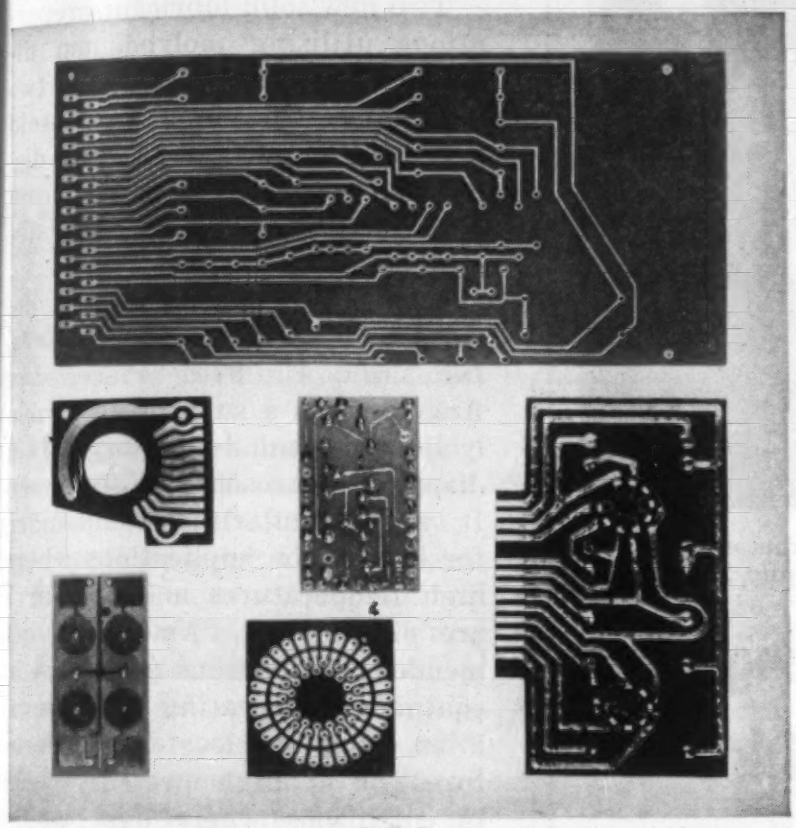
Lower Cost Titanium Addition Agent

A new grade of titanium metal designed for use as an addition agent in the manufacture of ferrous and nonferrous alloys has been developed by *E. I. du Pont de Nemours and Co., Inc.*, Wilmington, Del. According to the company, the product is an improved material at a lower price than non-ductile grades previously offered.

Designated Titanium Metal-Grade NDA, the material comes in two forms: pellets at $1.75 per lb and fines at $1.50. It has a minimum titanium content of 97% and maximum content of 3 iron, 0.2 nitrogen, 0.15% carbon and 75 parts per million of hydrogen. The pellets, ½-in. in diameter and ¼ in. thick, are unsintered compacts of titanium metal particles and run to about 100 lb per cu ft. They may be used effectively as ladle additions in production of 300 series stainless steels and in high temperature alloys. Fines are -14 mesh particles of spongy character and are used in specialized processes.

(More New Materials on p. 160)

For the most dependable printed circuits, you need the high bond strength, workability, heat-resistance of C-D-F DILECTO® METAL-CLAD LAMINATES



Printed circuits based on C-D-F materials are being used with great success in military electronic equipment, commercial television and radio sets, telephone switchboards—even sub-miniature radiosonde equipment and hearing aids.

Photos courtesy of Photocircuits, Inc., Glen Cove, N. Y.

HIGH BOND STRENGTH—C-D-F's special adhesive for metal-clad Dilecto bonds the copper foil to the plastic without affecting the laminate's superior electrical properties. Heat-resistance, dissipation factor, dielectric constant, dielectric strength, and insulation resistance of the Dilecto base remain unaffected. The closely-bonded foil can be etched cleanly and dipped in hot solder to 220°C. (428°F.) for ten seconds with a guarantee of no blistering or separating. Metal-Clad Dilecto can be punched or machined either before or after etching.

EXCELLENT WORKABILITY—On all five Dilecto metal-clad grades, you can solder, punch, saw, and assemble components either by hand or automatically. Thanks to the inherently superior workability of the plastics laminate over that of ceramic-type materials, Dilecto can be dropped, jammed into tight chassis, and otherwise treated roughly on the assembly line and in service.

HIGH HEAT-RESISTANCE—Metal-Clad Dilecto Laminates are made of phenolic, epoxy, or Teflon* resin for various conditions of service and assembly, and have either cellulosic paper or woven glass-fabric base. All are ideally suited to printed-circuit applications in which heat-dissipation is a major problem. Continuous exposure to high ambient operating temperatures in enclosed electronic equipment has no significant effects on Dilecto's electrical and physical properties.

UNLOAD YOUR HEADACHE HERE! C-D-F, a big, reliable source of supply, can help you get the most for your printed-circuit money by reducing rejects, lowering fabrication costs, assuring dependable quality every time. Send us your print or problem, and we'll gladly supply appropriate test samples free. See our catalog in the Product Design File (Sweet's) or send for the new 20-page Dilecto catalog. Let your nearby C-D-F sales engineer (listed in Sweet's) help you right from the design stage!

TYPICAL PROPERTY VALUES

	Copper-Clad PHENOLIC (Grade XXXP-26)	Copper-Clad PHENOLIC (Grade XXXP-24)	Copper-Clad EPOXY (Grade GB-116E)	Copper-Clad EPOXY (Grade GB-181E)	Copper-Clad TEFLON* (Grade GB-116T)
BOND STRENGTH—0.0014" foil (Lbs. reqd. to separate 1" width of foil from laminate)	5 to 8	5 to 8	8 to 12	8 to 12	5 to 8
MAXIMUM CONTINUOUS OPERATING TEMP. (Deg. C.)	120	120	150	150	200
DIELECTRIC STRENGTH (Maximum voltage per mil.)	800	800	700	650	700
INSULATION RESISTANCE (Megohms) 96 hrs. at 35°C. & 90¾ RH	50,000	50,000	30,000	20,000	Over 10^6 megohms
DIELECTRIC CONSTANT 10^6 Cycles	4.20	4.20	4.90	4.95	2.85
DISSIPATION FACTOR 10^6 Cycles	0.026	0.026	0.019	0.018	0.0006
ARC-RESISTANCE (Seconds)	10	10	60	80	180
TENSILE STRENGTH (psi.)	16,000 x 13,000	14,000 x 11,000	46,000 x 42,000	48,000 x 44,000	23,000 x 21,000
FLEXURAL STRENGTH (psi.)	21,000 x 18,000	19,000 x 16,000	60,000 x 55,000	75,000 x 65,000	13,000 x 11,000
IZOD IMPACT STRENGTH edgewise (ft. lbs. per inch of notch)	0.40 x 0.35	0.40 x 0.35	6.5 x 6.0	13.5 x 11.5	6.0 x 5.0
COMPRESSIVE STRENGTH flatwise (psi.)	28,000	27,000	60,000	62,000	20,000
BASE MATERIAL OF LAMINATE	Cotton rag paper	Cotton rag paper	Fine-weave, medium-weight glass cloth	Medium-weave, medium-weight glass cloth	Fine-weave, medium-weight glass cloth
COLOR OF UNCLAD LAMINATE	Natural greenish	Natural Brown	Natural	Natural	Natural

All these standard grades are available with 0.0014", 0.0028", 0.0042", or thicker electrolytic or rolled copper foil on one or both surfaces. Other metal foils and other resin-and-base combinations can be supplied on special order.

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CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

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Placing a cured preform for a case onto the heated matched metal mold. Polyester resin is added and the final cure made at 100 PSI and 235° F.

8-corner drop test proves strength of plastic case reinforced with L·O·F Glass Fibers' Garan® Roving

Testing of plastic instrument cases to meet government specifications requires a severe 8-corner drop test. Cases are loaded with 74 pounds of weight, then dropped four feet on each of the eight corners.

These cases, produced by the Chemold Company of Santa Monica, must have unusual strength and weather resistance. They are designed to protect delicate equipment from rough handling and extreme climatic changes.

Mr. L. R. Dailey, Chemold Director of Research, says, "L·O·F Garanized glass fibers have made it possible for our products to demonstrate superior physical properties under both wet and dry conditions."

Here's how L·O·F Glass Fibers' Garanized and chrome roving can improve your product and process:

- Provide high wet-strength retention
- Improve flexural, compressive and tensile strength
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- Wet out completely, permit fast molding cycles

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For technical data and information on standard packages, contact our nearest sales office, or write: L·O·F Glass Fibers Company, Dept. 37-85, 1810 Madison Avenue, Toledo 1, Ohio.

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L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY
TOLEDO 1, OHIO

Makers of glass fibers by the exclusive "Electronic-Extrusion" process.

For more information, turn to Reader Service Card, Circle No. 329

New Materials, Parts, Finishes

New Solid Lubricants

Two new solid lubricant preparations utilizing molybdenum disulfide have been developed by two companies. One is a suspensoid packaged in an aerosol-type dispenser, the other is in the form of a dispersion in an adhesive petroleum oil.

Type PT-101, Moly Spray, developed by *Product Techniques, Inc.*, 511 E. 87th Place, Los Angeles 3, is a suspensoid of molybdenum disulfide, packaged in a disposable aerosol-type dispenser. It is particularly recommended for lubrication applications where high temperatures and pressures are encountered. Among recommended applications are: 1) in equipment operating in ovens, kilns, etc., at elevated temperatures or at high pressures; 2) in conditions where dust would cause oils or greases to be injurious or ineffective; 3) in conditions involving subzero temperatures or partial vacuums; 4. spraying rubber seals to prevent their sticking to other surfaces; and 5) lubrication of dies for forming alloy and carbon steels to prevent galling and to lengthen die life.

Molykote 165X, developed by *The Alpha Molykote Corp.*, 65 Harvard Ave., Stamford, Conn., is a near-colloidal dispersion of molybdenum disulfide in a viscous, tacky adhesive petroleum oil which is rendered fluid by addition of a volatile, non-flammable diluent. Evaporation of the diluent leaves a plastic film that does not tend to hold dust and cannot be readily washed off by water. According to the company, the film will not crack or peel at temperatures as low as zero F. It is particularly recommended for application on highly loaded gears which normally can only be lubricated infrequently. Also, it is said to be particularly useful where only one or two gears of a long gear train are exposed and lubrication must be achieved through transfer of lubricant from gear to gear.

For more information, Circle No. 461 ➤

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- *Properties of cellular polyethylene*
- *Effects of rare earths on cobalt alloy*
- *Latest developments in electroplating*
- *Titanium fabrication*

Why Cellular Polyethylene?

Cellular polyethylene resin was developed for certain applications requiring properties not obtainable from the solid material. By combining polyethylene properly with an inert gas, a cellular structure consisting of discrete cells of gas in the polyethylene resin is obtained. Properties of the base resin are thus changed to achieve lighter weight, lower dielectric constant, lower thermal conductivity and greater bouyancy with little or no sacrifice in chemical inertness, moisture resistance, low temperature behavior or power factor. The general properties of this material are discussed by W. T. Higgins of Bakelite Co. in last January's issue of *SPE Journal*. Higgins points out that normal extrusion equipment does an excellent job and only a few changes in technique are necessary to produce a good product.

COMPARATIVE PROPERTIES OF CELLULAR POLYETHYLENE

	Solid Polyethylene	Cellular Polyethylene
Specific Gravity	0.92	0.47
Tensile Str, psi at 23°C	2180	670
Elong, % at 23° C	580	310
Dielectric Str, ASTM D149-44		
Short Time, at 0.125 in, v/mil	630	220
Step by Step, at 0.125 in, v/mil	590	190
−55° C Mandrel Bend, 2X	OK	OK
Power Factor, at 1000 cycles	0.00028	0.00033
at 10,000 cycles	0.00030	0.00038
Dielectric Const., at 1000 cycles	2.3	1.48
at 10,000 cycles	2.3	1.49
Thermal Cond, Cal/cm²/sec/°C/CM	8.0×10^{-4}	2.8×10^{-4}

Properties compared

Because cellular polyethylene is 50% gas, certain properties of polyethylene will be degraded while others are improved. The accompanying table compares some typical properties of the expanded resin with those of the solid. As can be seen, tensile strength, elongation and dielectric strength of cellular compositions are lower than those of solid resins, though they are still in a useful range. Power factor values are essentially the same. Dielectric constant is much lower, hence the cellular material exhibits lower dielectric losses than solid polyethylene. Low density is desirable where reduced cost and weight, decreased thermal conductivity and increased bouyancy are important.

Because each gas cell is completely closed, moisture permeability of the material approaches that of the solid material. Although the former picks up water rapidly at first, once the relatively few open surface cells are filled, no further increase in absorption occurs. Both power factor and dielectric constant show little, if any, response to changes in frequency. This is particularly important in applications such as the recently developed cellular polyethylene antenna lead-in wire for UHF applications since irregularities in either of these properties will result in power losses in the range of frequencies where the irregularities occur. In practice, power losses might result in poor reception due to a weak signal.

Where densities higher than 0.47 are required, cellular stock may be blended with solid compounds to obtain the desired density. While it is possible to get higher densities by extruding at reduced temperatures, thus limiting the extent of blowing, it has been found extremely difficult to reproduce results.

Misch Metal Improves High Temperature Alloy

In the continuing search for better high temperature materials, an investigation was carried out at the Naval Research Lab to determine the effect of rare earth additions on the high temperature properties of a cobalt-base alloy. Results of the investigation are summarized in a paper by J. E. Breen and J. R. Lane of the Metallurgy Div. of NRL, delivered before the 58th annual meeting of the American Society for Testing Materials held recently in Atlantic City. Tests indicated material improvement in high temperature

Contents Noted

properties and negligible improvements in room temperature tensile properties. The acccmpanying table shows 100-hr rupture strength and elongation of specimens in various heat-treat conditions, with varying percentage of rare earth additions, tested at 3 different temperatures.

Chemical composition of the alloy tested was: 0.37 carbon, 55.6 cobalt, 10.4 nickel, 25.5 chromium, 7.1 tungsten, 0.53 manganese, 0.52 silicon, 0.021 oxygen, 0.027 nitrogen, and 0.0006% hydrogen. Tests were made on precision cast specimens, specimens machined from 15-lb ingots and specimens forged from these ingots.

EFFECT OF RARE EARTH ADDITIONS ON 100-HR RUPTURE STRENGTH
(Precision-Cast Heat)

Rare Earth Added, %	Temperature, °F	Heat Treatment	Stress to Produce Fracture in 100 hr, psi	Elongation, %
0.0	1500	As cast	24 200	5.0
0.5	1500		27 300	15.6
2.0	1500		29 000	14.6
0.0	1600		17 900	4.0
0.5	1600		18 400	10.0
2.0	1600		21 100	13.4
0.0	1700		13 500	6.0
0.5	1700		14 500	7.5
2.0	1700		15 700	10.0
0.0	1500	Aged	25 400	4.6
0.5	1500		28 600	13.0
2.0	1500		30 900	15.2
0.0	1700		13 800	1.8
0.5	1700		14 200	9.0
2.0	1700		15 300	10.0

Results summarized

Rupture strength at elevated temperatures was increased by the misch metal additions in all proportions tried. Strength increase was greater at 1500 F than at either 1600 or 1700 F. Ductility was generally improved, though at 1500 F there appeared to be a maximum in the elongation curve at above 0.5% rare earth added (0.12% retained). In no case was ductility less than that of the original alloy. Improvement of ductility was greatest at 1500 F, least at 1700 F. Relative gain in ductility due to rare earth tended to be greater as stress was increased. Forgeability was not improved; on the contrary, additions seemed to impair hot-working characteristics. Minimum creep rate was lowered by a sufficiently large addition of rare earths, while a smaller amount may increase the rate. Room-temperature tensile properties remain relatively unchanged.

(More Contents Noted on p. 166)

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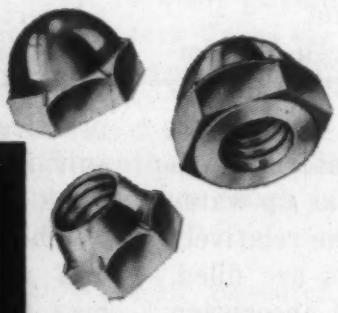

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Diameters up to 9/64" lengths up to 5/16"
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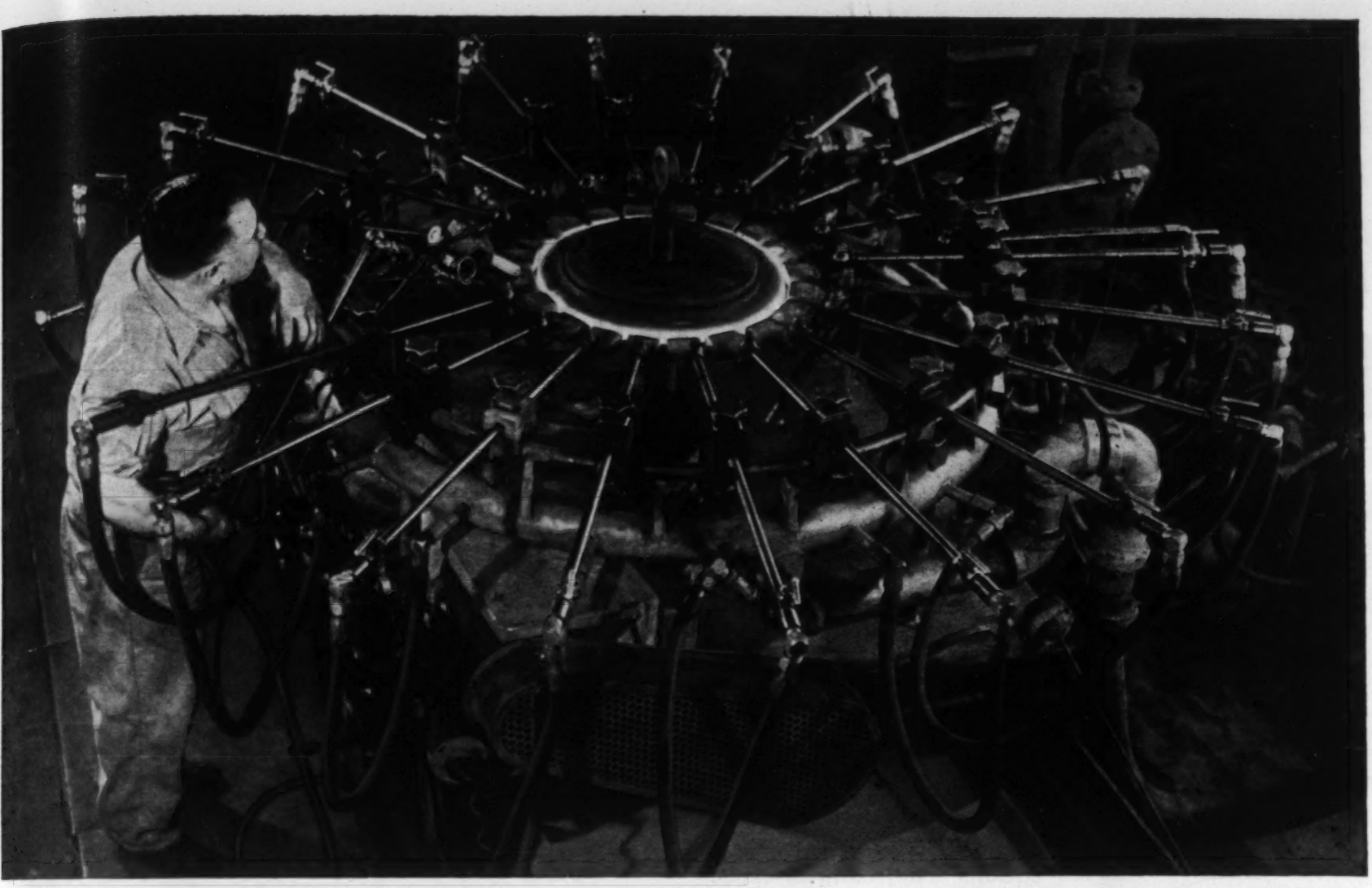
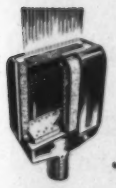


Flame hardening set-up shows an application of Selas "Superheat" burners at the Wiedermann Machine Co., Philadelphia. With burners grouped like this, high temperature effects are intense. In this service, Inconel jackets give 5 times the life of any other alloy tried.

Sheathed with Inconel

these "Superheat" Burners last 5 times longer



"Inconel shells mean big savings for our customers," Selas says

These "vest-pocket" Selas furnaces blast out heat at rates on the order of 2000 feet per second . . . 40,000,000 BTU/ft³. Jet action is so strong, work pieces are sometimes heated, formed, and delivered by thermal impact alone.

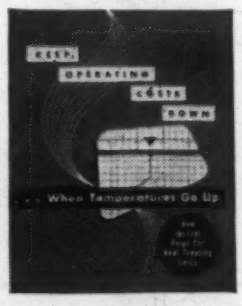
Metal burner shells used to burn out fast. In one severe application, jackets averaged only 100 hours. Now, Inconel sheathing gives a minimum of 500 hours.

"In this operation (surface hardening)," says Selas, "Inconel shells cut costs approximately 70%."

What's hot in your shop?

Whatever it may be, chances are, Inconel can handle it. Here are three reasons why:

1. Inconel stays usefully strong up to 2100°F., resists thermal shock.
2. Inconel resists oxidation, hydrogen embrittlement, many other types of corrosion.
3. Inconel is easy to form, machine, weld . . . available in all commercial forms.



A new Inco booklet, "Keep operating costs down, when temperatures go up" suggests many ways to use Inconel and other Inco heat resisting alloys effectively. Dozens of types of equipment shown. Write for a copy.

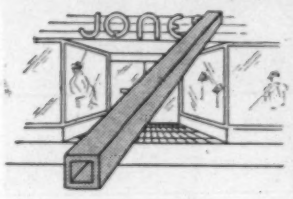
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

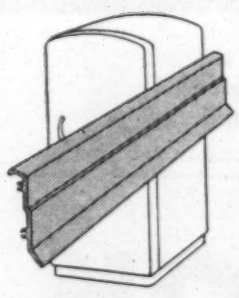
INCO TRADE MARK **Nickel Alloys**

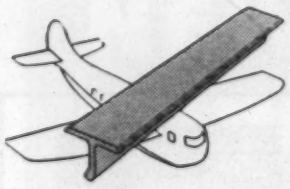
Inconel . . . ***for long life at high temperature***

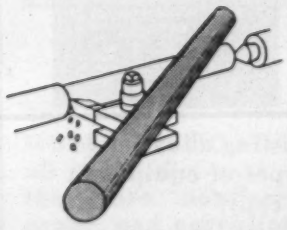
Extrusioneering

THE PLUS VALUE OF PE SERVICE









★ Precision "Extrusioneering" is an expanded aluminum extrusion service designed to assist you in developing new ideas to cut manufacturing costs and improve product quality. A competent staff of PE engineers, with broad practical experience in all types of fabricating operations, are available to work with you in analyzing your need for possible cost-cutting extrusion applications. They can, for example, help you reduce fabricating costs, simplify assembly problems, eliminate machining operations, or provide greater strength and stability for your product.

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Contents Noted

Electroplaters Discuss Latest Developments

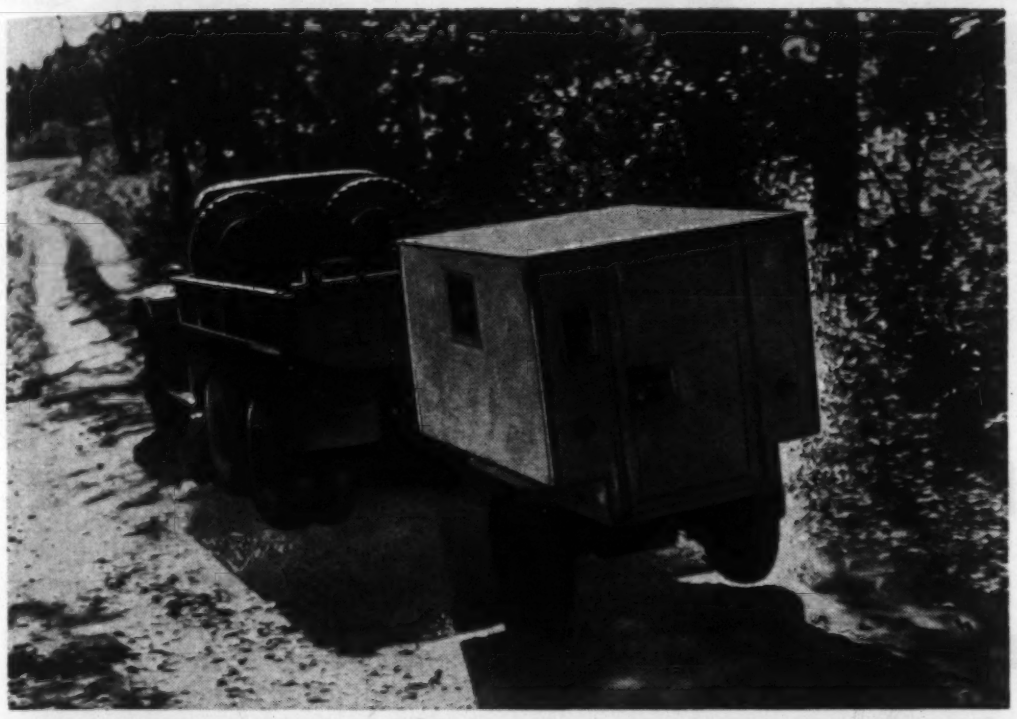
Latest developments in electroplates and electroplating techniques were described recently in a series of papers delivered before the 42nd annual meeting of the American Electroplaters' Society in Cleveland. Some of the more interesting papers outlined: 1) electrophoretic deposition methods which permit rapid build-up of coatings with only small expenditures of current; 2) two new electroplates, one a lead-tin-antimony alloy for bearing surfaces, the other a diffused nickel-cadmium plate for corrosion protection; 3) use of ultrasonic vibrations to increase plating rates and reduce sensitivity of plating adherence to cleanliness of base surface; 4) a procedure for electroless nickel plating of ceramics; and 5) a modification of the sulfuric acid anodic etch, increasing adhesion of nickel plate to large parts. Digests of these papers follow.

Electrophoretic deposition

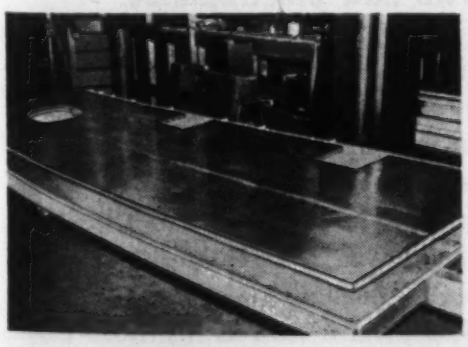
Still in experimental stages, electrophoretic deposition permits rapid build-up of thick metallic or composite coatings with only minute expenditures of electric current, i.e., current densities of 0.05 to 0.3 amp per sq ft. Described in a paper by J. J. Shyne, H. N. Barr, W. D. Fletcher and H. G. Sheible, of Vitro Corp., the new technique deposits particles rather than the conventional ions and therefore requires much less electric current. Use of organic suspensions instead of aqueous solutions makes possible voltages on the order of 200 to 1000 v d.c., resulting in deposition of 2 to 5 mils in as little as 20 to 40 sec.

The deposit is in the form of a packed layer of powder which is about 50% porous and must be filled in. One method of densifying the coating is to deposit a metal oxide that can then be reduced by hydrogen in a sintering operation. For example, a mixture of nickel oxide and chromium

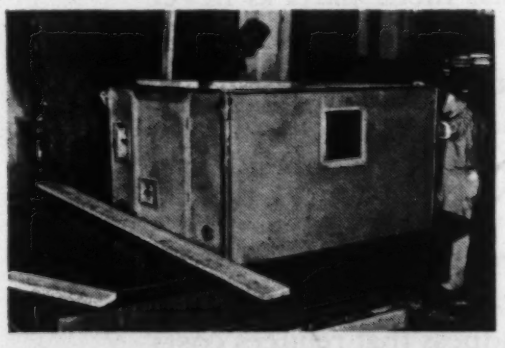
Air traffic control system made by CRAIG MACHINE, INC., gains high strength, all-weather protection with sandwich walls of NOPCO® LOCKFOAM



These light-weight vehicles really have to stand the bumps on any kind of road—and they do. In the factory, a 10-inch drop test onto solid concrete fails to loosen the Lockfoam's firm adhesion to the aluminum 'skin'.



Ease of construction. Illustration shows wall panel after top of mold has been removed. Lockfoam is poured between the aluminum sheets, completely filling the cavity —then solidifies.



Like water off a duck's back. In this test, the shelter is placed in a water tank and left for several hours. Because of its unicellular structure, Lockfoam resists water-sorption, a highly desirable characteristic in case of damage to the outer shell.

Shelters of the mobile air traffic control system made by Craig Machine, Inc., Danvers, Mass., carry sensitive electronic equipment, to guide planes into airfields. In building them Craig found, as many others have found, that Lockfoam's ease of handling, its pour-in-place technique, offer important performance advantages and production economies over other plastics. Sandwiched between two sheets of aluminum, Lockfoam gives great strength and rigidity with light weight, and adheres firmly to the aluminum surrounding it. Lockfoam's low thermal conductivity insulates effectively against the weather.

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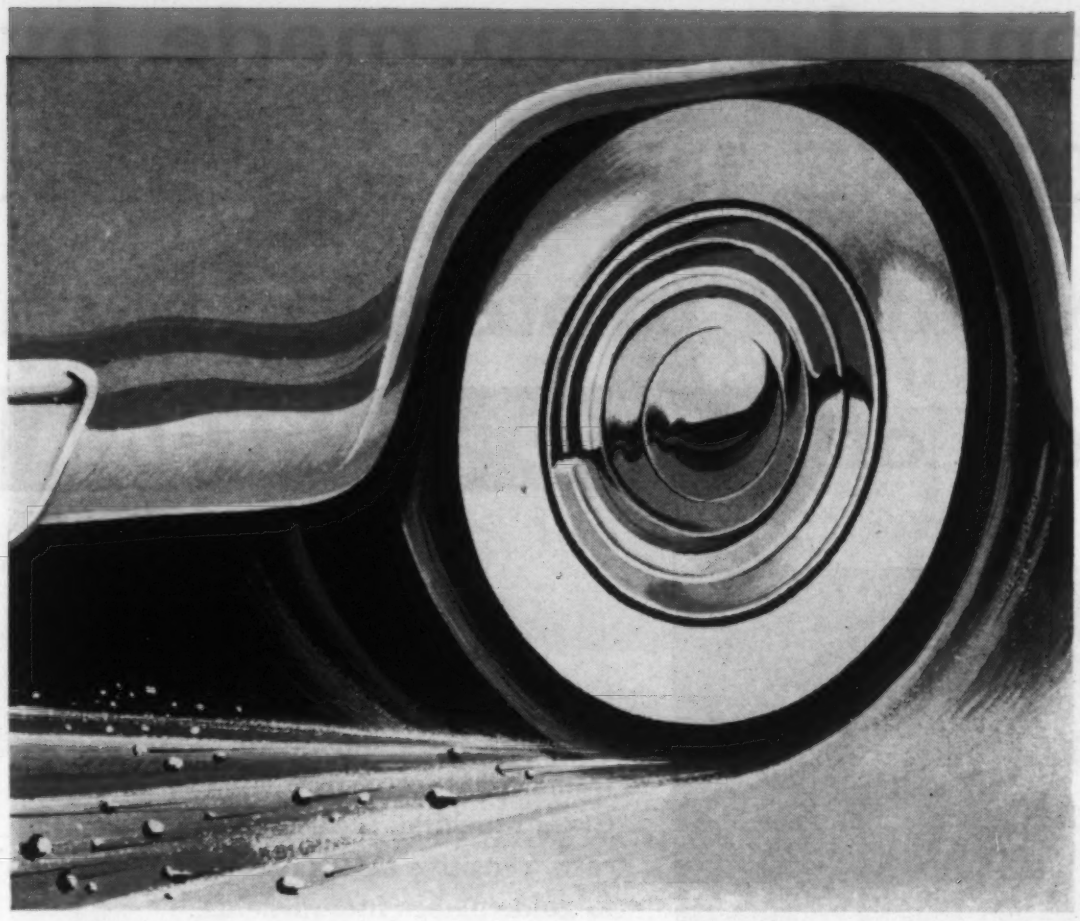

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powders can be sintered at 1480 F. Another way is to electrodeposit metal through the pores. For example, nickel can be deposited through the pores of silicon carbide. In some cases, the deposit can be mechanically worked to obtain similar results.

Coatings are deposited from a 10% suspension produced by ball milling the powders in an organic liquid. The particles acquire their electric charge during the milling operation. When depositing composite coatings, the ratio of metals in the resultant deposit will be the same as the ratio of powders in suspension. Etching or sandblasting surfaces prior to coating is recommended where coating thickness is to exceed 1 mil.

The technique seems particularly adaptable for applying hydrogen-reducible metal oxides, such as chromium, nickel, iron and cobalt. Tungsten and silicon carbides, molybdenum disulfide and cermets also seem feasible. Though economics of the process have not yet been determined, the authors believe it will prove to be comparable to electroplating in cost.

Two new electroplates

Two new electroplates, a lead-tin-antimony alloy for bearing surfaces, and a diffused nickel-cadmium plate for corrosion protection, have been developed by engineers of Pratt & Whitney Aircraft Co. The lead-tin-antimony plate, described in a paper by R. T. Putnam and E. J. Roser, does not have the load-carrying ability of lead-indium, but offers greater hardness and resistance to corrosion and erosion. These properties are particularly important in jet engines where bearing surfaces may be subjected to high temperatures and high-velocity gas flow. Plates analyze about 11 tin, 7 antimony, 92% lead. Composition can be adjusted by altering current density, i.e., lowering current density increases antimony and lowers tin content. The authors point out that prolonged exposure to elevated temperatures tends to reduce the amount of tin in the plate. For example, the

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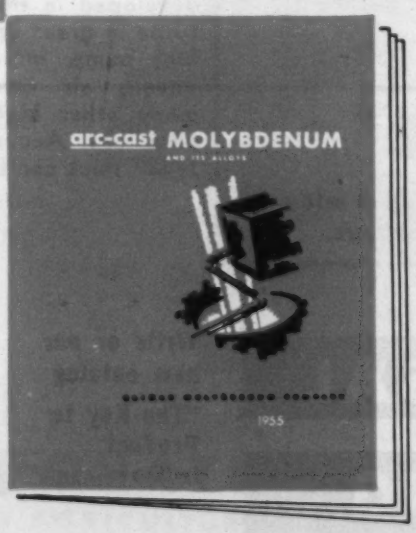

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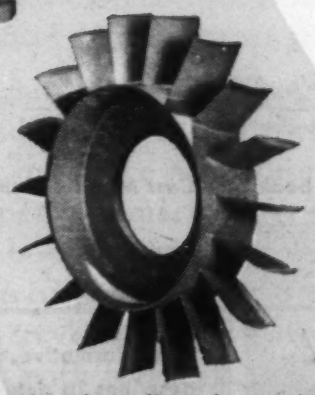

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amount of tin in a plate exposed at 300 F for 500 hr was reduced from about 11% to about 8%. This is attributed to alloying of tin with the silver base.

The diffused nickel-cadmium coating described in a paper by R. W. Moeller and W. A. Snell, was developed to avoid destructive "stress alloying" which can occur when cadmium plated constructional steels are used at temperatures above 600 F. If the part is highly stressed the result may be almost instantaneous failure. Apparently the failure results from intergranular alloying of the steel with the molten cadmium (cadmium melts at just above 600 F). By avoiding direct contact between cadmium and steel, the new coating eliminates the possibility of stress alloying and also provides better corrosion resistance than either nickel or cadmium alone. It seems to be suitable for exposure to temperatures up to 1000 F.

The plate requires a 4-step process: 1) plating 0.2-0.4 mils of nickel from a normal Watts-type bath; 2) plating 0.1-0.2 mils of cadmium from a cyanide bath; 3) dipping in chromate conversion bath to eliminate "fingerprinting" on the cadmium; and 4) baking at 630 F for 1 hr to diffuse the cadmium into the nickel. Resulting plates consist of a nickel layer, an undetermined bonding layer which may be $NiCd_7$, and an outer layer of cadmium oxide. Lack of complete diffusion is not detrimental since the excess cadmium is converted to cadmium oxide. Later discussion brought up the possibility of a process refinement consisting of use of a protective atmosphere to prevent oxidation of cadmium prior to its diffusion into the nickel. According to Moeller, the nickel-cadmium plate seems to be at least as good as a proprietary nickel-zinc plate and its corrosion products are not nearly as bulky.

Both the lead-tin-antimony and the diffused nickel-cadmium plates have been successfully applied in

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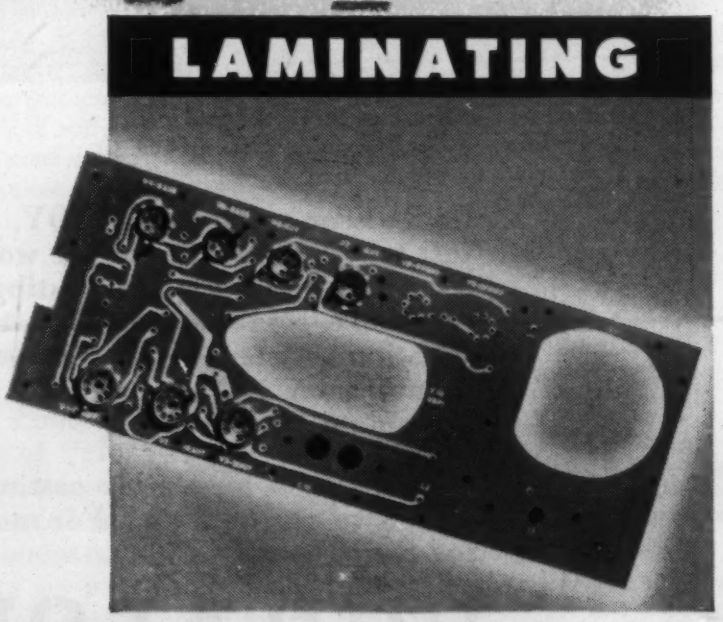

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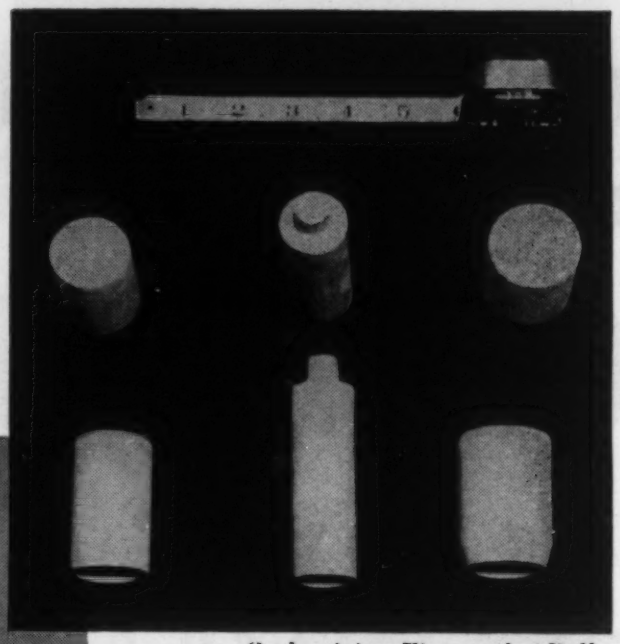

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Analysis 35% Ni — 15% Cr

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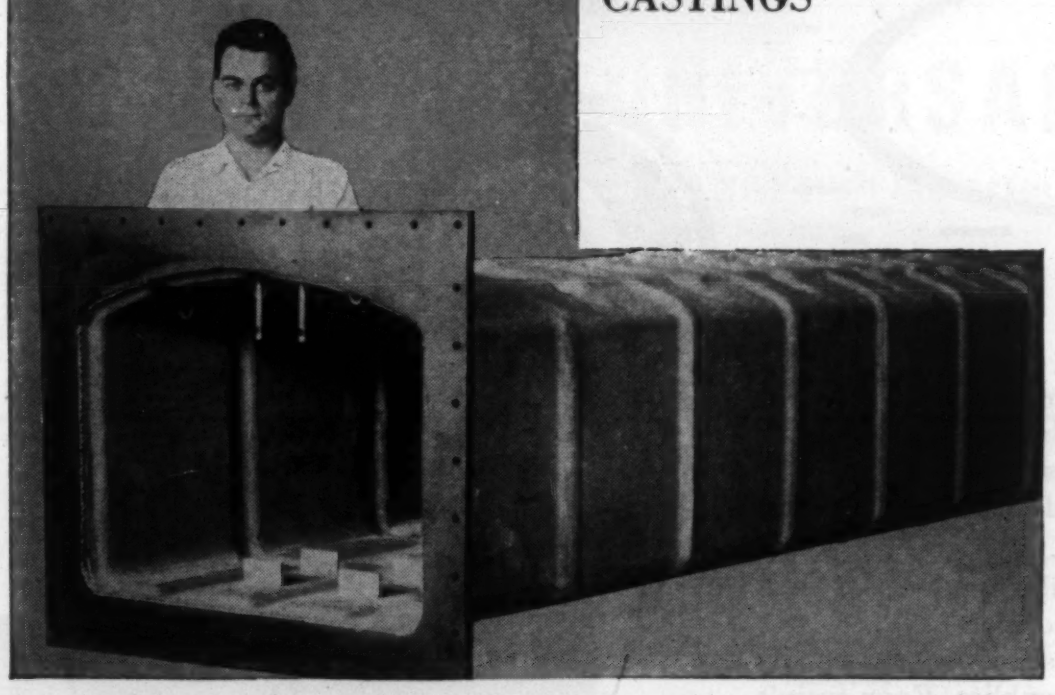

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production. The latter is the subject of an AMS specification to appear shortly.

Ultrasonics speed plating

Ultrasonic vibrations can increase plating rates up to about 20 times the normal speed of deposition and also make successful plating less dependent on cleanliness of base metal surfaces, according to a preliminary investigation made by S. R. Rich of Rich-Roth Labs. Rich explained that accelerated deposition rates were due to the scrubbing effect of ultrasonic pulses in liquids, which rapidly replenishes stagnant layers of electrolyte adjacent to anode and cathode surfaces. Ultrasonic waves permit the current density to be increased up to 20 times normal values without adverse effect on the plate. The author cites as examples plating rates of 0.2-0.3 mils of cadmium in 2 min, and in one case up to 1 mil in 2 min. Also, 1 mil of electroless nickel can be plated in about 15 min. Polarization is reduced resulting in steady current throughout plating, and edge build-up is eliminated. Improvements have been realized in both electroplating and in electroless plating.

Rich also found that badly contaminated surfaces could be plated successfully, which suggests the possibility of cleaning and plating simultaneously. Though this would probably not be recommended as standard practice, results indicate that plating rejects or failures due to faulty cleaning could be cut substantially. Metals successfully plated include cadmium, zinc, nickel, chromium and silver. Best results were obtained with alkaline cyanide baths and Watts-type nickel baths.

Significant differences were found in plates produced at different ultrasonic frequencies. Although high frequencies such as 400 kc provide greater particle acceleration, they tend to produce plates with alternate stripes resulting from standing waves. Lower frequencies such as 20 kc

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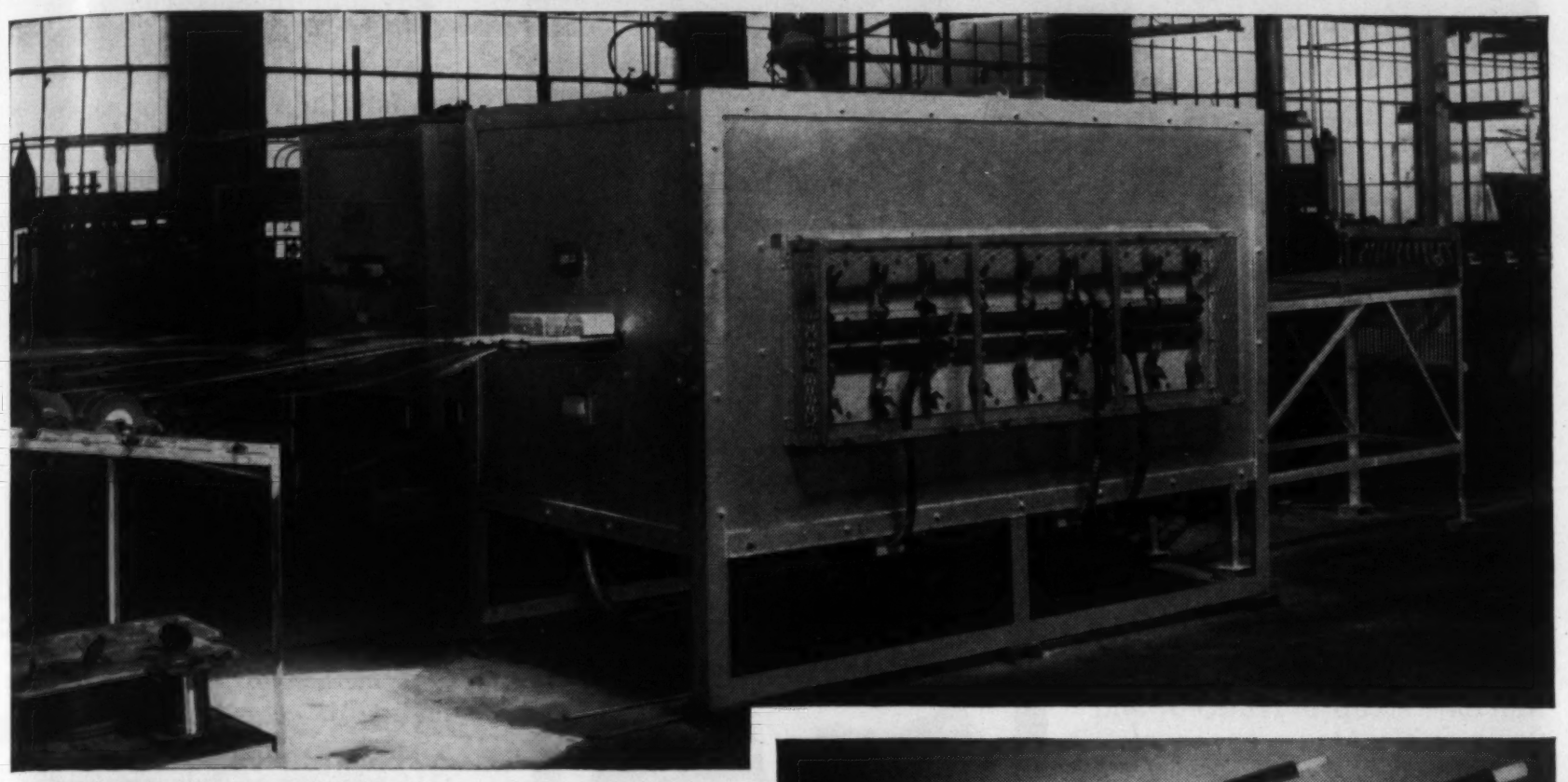

Completely Equipped With "Hot Rods" after Norton CRYSTOLON heating elements proved their ability to outlast others 3 to 1. This electric furnace is one of a battery operated by the Alloy Metal Wire Division of H. K. Porter Company, Inc. of Prospect Park, Pa., for bright annealing alloy wire at 2150F. Heating elements operate in an air atmosphere, while the wire passes through tubes containing a controlled split-ammonia atmosphere. These furnaces idle at 1700F-1750F on weekends and holidays, so element service is continuous.

Alloy Metal Wire Division H. K. Porter Company, Inc. converts to CRYSTOLON heating elements after tests prove superiority of latest Norton Rx*

Like many another new user of "Hot Rods" the Alloy Metal Wire Division of H. K. Porter Company, Inc. found that these Norton CRYSTOLON heating elements last much longer. Here is a summary of the tests responsible for this company's decision to make a complete change-over to "Hot Rods."

Electric furnaces at the company's Prospect Park plant are used for bright annealing alloy wire at 2150F. Previous heating elements had given approximately 4 to 6 months service with 3,048 hours as the best recorded service life. Then, in a furnace completely equipped with "Hot Rods" the Norton elements averaged 18 months of continuous service — or over 13,000 hours per element. Once again "Hot Rods" proved their ability to outlast competitive elements — by better than 3 to 1!

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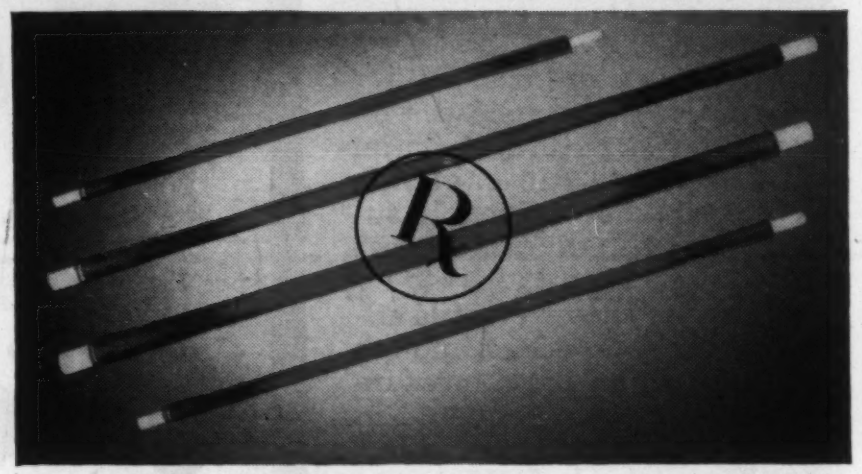

Norton CRYSTOLON Heating Elements, or "Hot Rods", are a typical Norton Rx — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

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- are made in complex shapes
- have consistent uniformity
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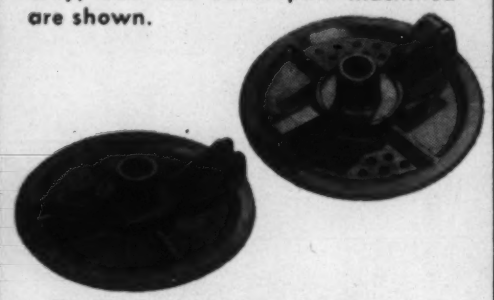
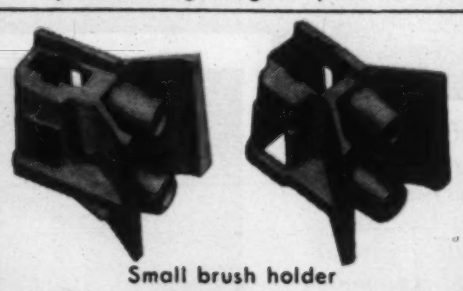
VISUAL PROOF

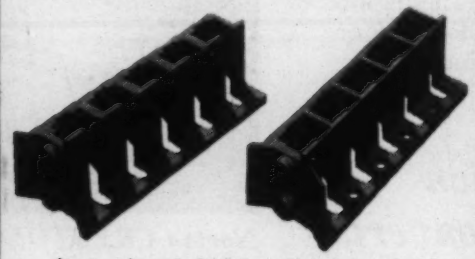
These photos demonstrate how little secondary machining is required on typical Titan pressure die castings. In each case a part as cast and trimmed only, and the same part machined are shown.



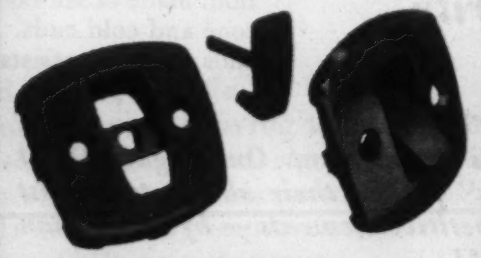
Flywheel for garbage disposal unit



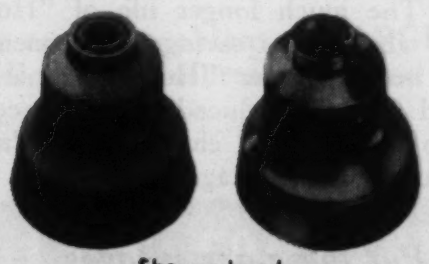
Small brush holder



Large brush holder with broached holes held to close tolerance



Overflow plate and trip handle



Shower head

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produce waves of greater amplitude which seem to have more "curvature", i.e., they require less focusing and therefore result in more uniform-appearing plates.

Rich acknowledged that ultrasonic vibrations bring the sludge up into the solution, but this does not seem to have any detrimental effect on the plate. Also, since conventional barium titanate transducers will not withstand many of the chemically active plating solutions, they must be completely enclosed in a stainless steel case which can be further protected by organic coatings where necessary. The author emphasized that ultrasonic techniques are expensive and would probably not be used where suitable mechanical agitation was feasible.

Electroless plating ceramics

A method of electroless nickel plating of ceramics, described in a paper by P. Eisenberg and H. C. Schneider of Sylvania Electric Products Co., consists of alkaline cleaning and chemical etching the ceramic surface. The surface is then "seated" by saturating the pores with a solution of sodium hypophosphite and the piece is immersed in an electroless plating solution. The bath is run at about 170 F with a pH of 4.5 to 6 resulting in a plating rate of about 0.5 mils per hr. Higher rates are obtainable at higher bath temperatures, but the bath is less stable. Plates ½ mil thick, roughly equivalent to 1 mil of electrodeposited nickel, have good adhesion and negligible porosity. Adhesion was tested by soft soldering copper wire to the plate and pulling it in a direction perpendicular to the plate. Porosity was determined by immersion in a 20% aqueous solution of sodium hydroxide for 124 hr and testing the resultant solution for products of reaction between the solution and the base ceramic body.

Modified sulfuric acid etch

A lower-cost modification of the sulfuric acid anodic etch results in nickel plate with excellent adhesion on large parts. Chrysler

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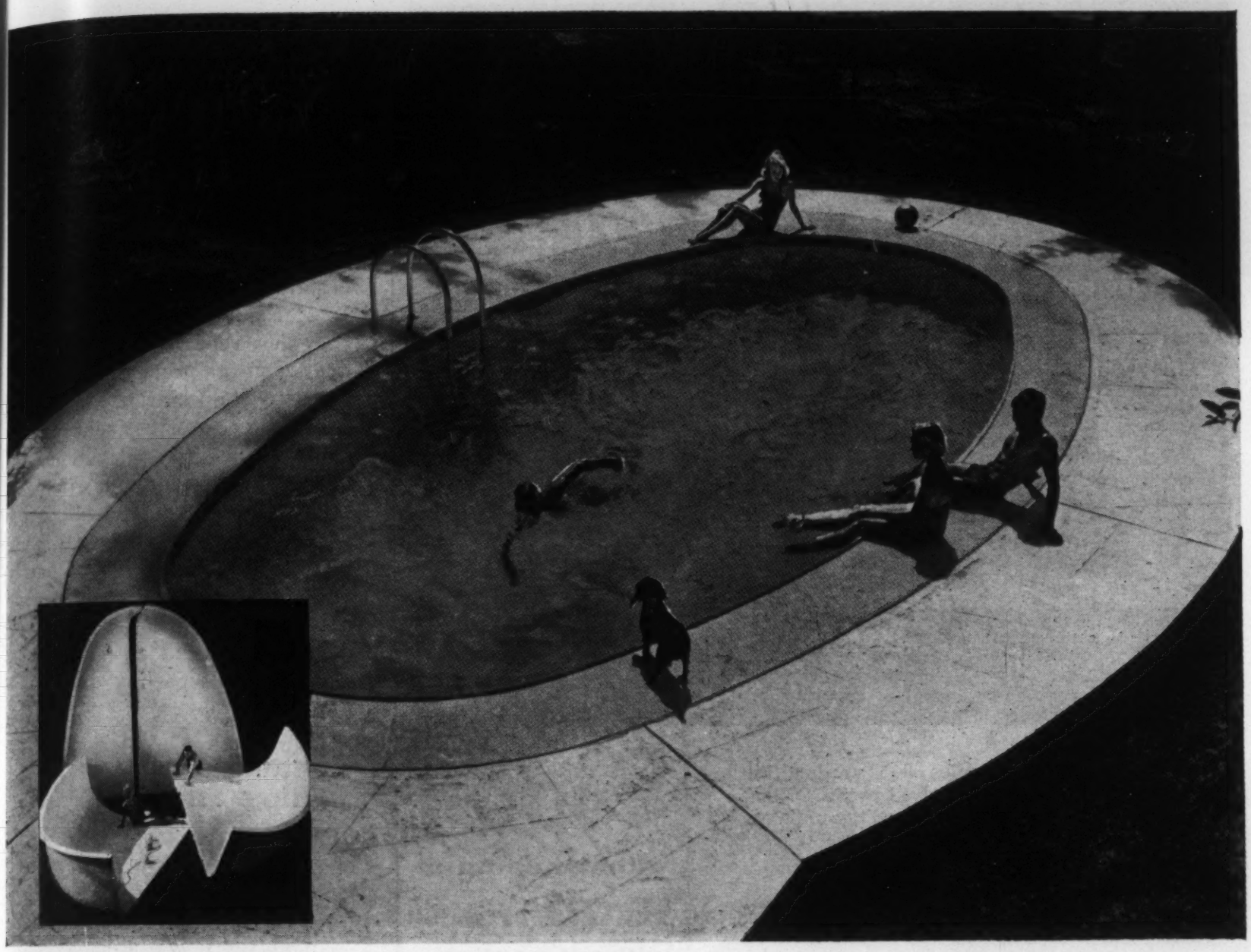

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152 Problems in HEAT RESISTANT FINISHES solved by Sicon

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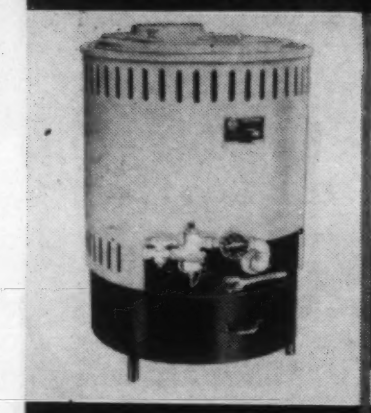

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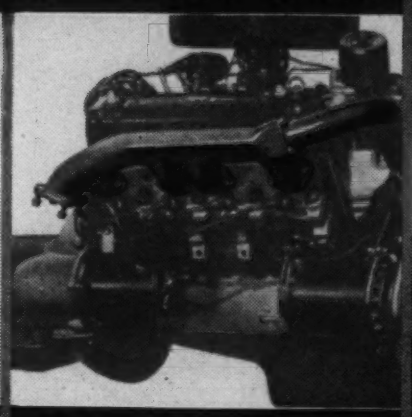

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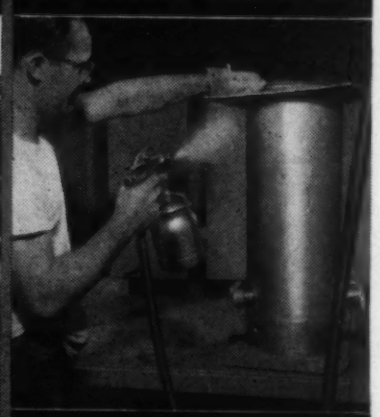

SICON Aluminum for jet engines. Protects up to 1000°F.

Shown above are examples of 152 product finish applications successfully solved by SICON last year after high temperatures had decomposed ordinary finishes. (See partial list below.)

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Contents Noted

engineers found the 125-200 amp per sq ft current density required in a straight sulfuric acid anodic etch solution resulted in need for excessive electrical capacity for certain large jet engine parts. V. L. McEnally and F. G. Brune of Chrysler reported on results of adding a high proportion of epsom salts to the solution, which reduced the cost of the solution and substantially lowered current requirements. Adhesion of nickel deposited over the etched surface was tested by bending. A 3-mil plate on a ¼-in. thick strip had to withstand a 180-deg bend around a 1-in. radius, followed by a 360-deg reverse bend as flat as possible, without peeling or flaking.

Forming and Joining Titanium

More information on forming characteristics, weldability, and riveting and dimpling specifications of titanium have been made available to industry as a result of a comprehensive study of the material by Ryan Aeronautical Co. under contract with the USAF. In the March issue of *Aeronautical Engineering Review*, D. Adams of Ryan describes some of the results obtained in these areas.

Forming characteristics

Experimenting with drop hammer forming, Ryan learned that parts other than those embodying shallow draws could not be cold-formed in the drop hammer because the impact caused fracture after relatively small amounts of deformation. Hot-forming was quite successful when a proper procedure was developed. Best results were obtained using standard methods of forming stainless steel parts. Kirksite dies and lead punches, jacketed with mild steel on contact faces and coated with a heavy-weight commercial oil were used with titanium blanks preheated to 1000 F.

This procedure proved conclusively that commercially pure titanium parts can be formed as satisfactorily as stainless steel

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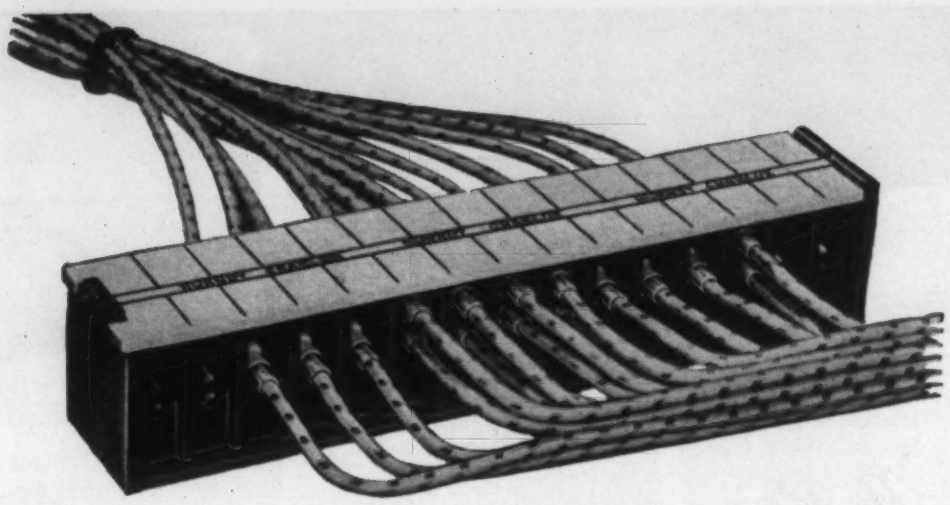
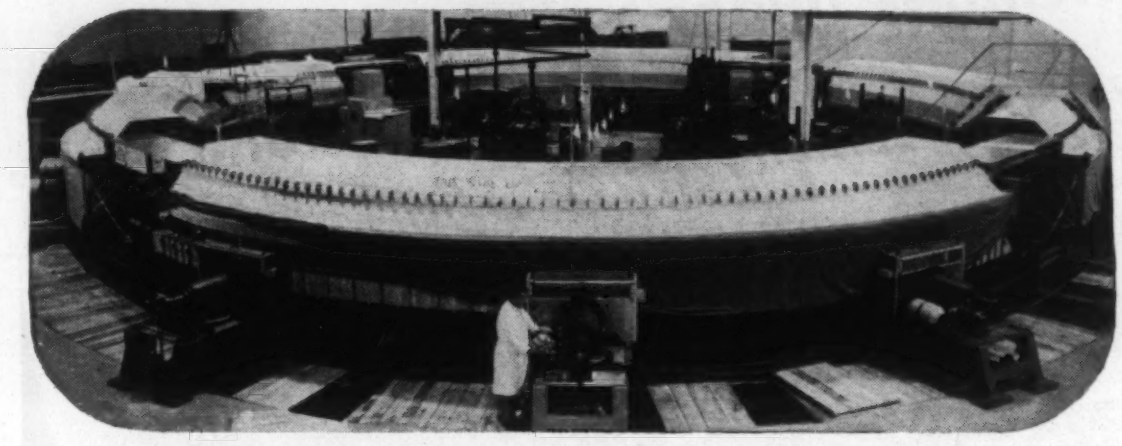


It takes lots of **GOOD CONNECTIONS**



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In the Brookhaven National Laboratory's "Cosmotron" at Upton, L. I., forty million watts accelerate nuclear particles to the heady speed of 170,000 miles per second in the interest of research.

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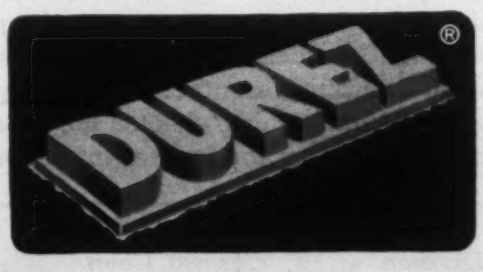

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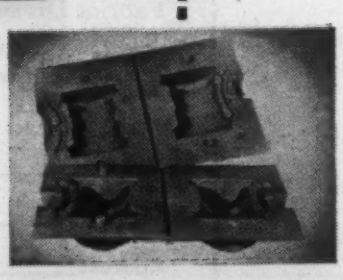

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Contents Noted

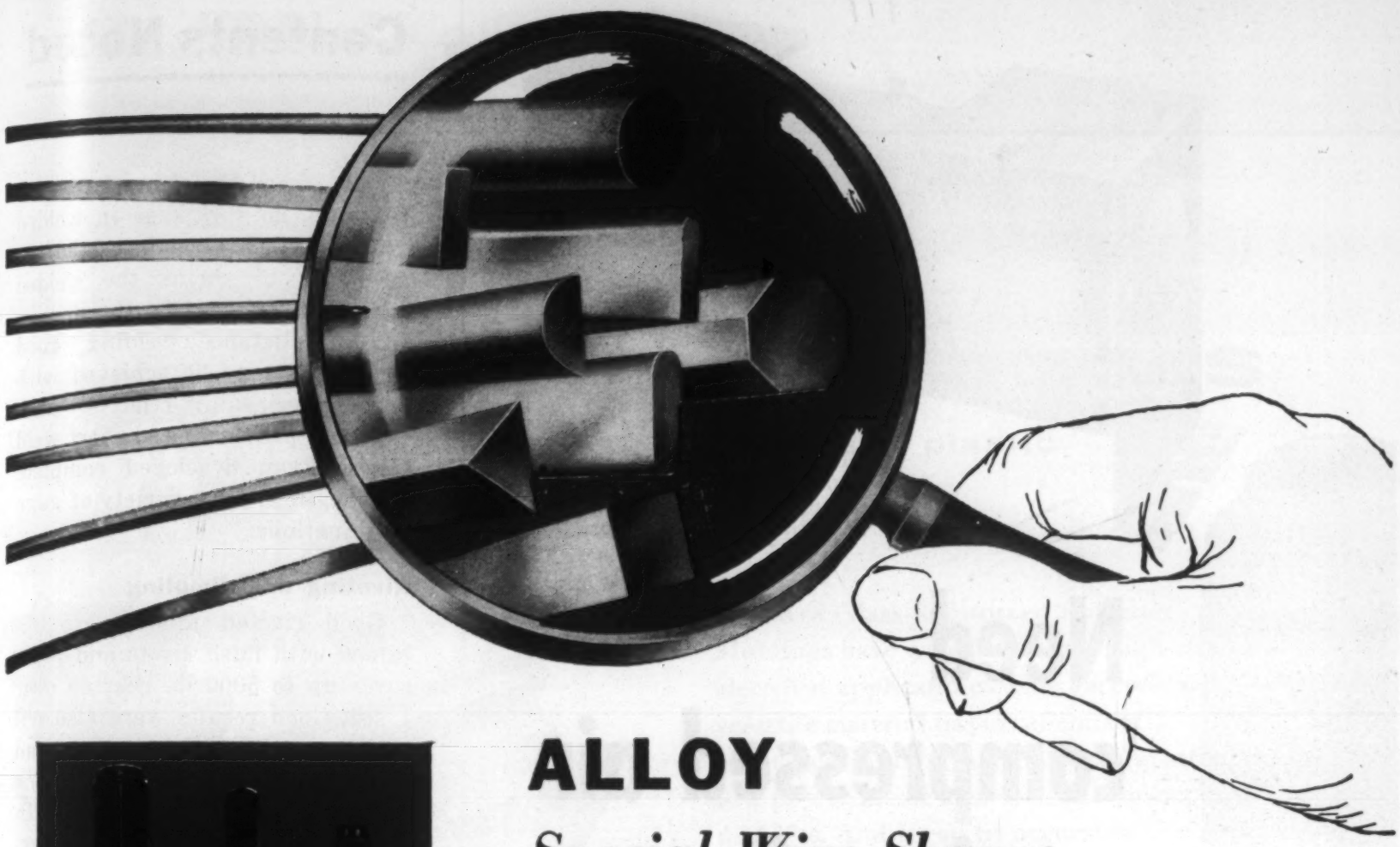
counterparts without basic engineering design changes other than judicious selection of edge and corner radii at abrupt contour changes and liberal use of stage dies. It is primarily important to maintain blank temperatures at about 700 F for optimum forming characteristics. Oxides produced by heating, as well as residual lubricants are successfully removed by immersion in an 800 F salt bath followed by a nitric-hydrofluoric rinse.

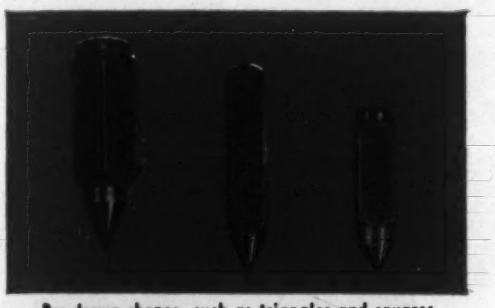
Cold-forming on punch presses requires greater attention to contour forming of the blanks to permit metal to flow to proper die contour. The most successful room temperature-forming was accomplished with copper-plated blanks that were dipped in a forming lubricant, or by using blanks coated with a film of colloidal graphite.

Strips of titanium were bent in a brake press to determine minimum bend radii. Samples 0.018-in. thick took a 1.7T bend in transverse and longitudinal directions without fracture. Minimum bend radii for 0.040-in. strips for longitudinal samples ranged from 1.66T to 2.35T, while transverse samples ranged from 1.70T to 2.54T. Finally for 0.125-in. material longitudinal samples ranged from 1.50T to 2.12T, and transverse samples 2.12T.

Weldability

Inert-gas-shielded welding is the only type of fusion welding which can be made on titanium while maintaining adequate physical properties. Molten titanium will react with, and be embrittled by all known welding fluxes as well as air. With gas shielding, welds of good quality, in which welds were found to be stronger than the parent metal were obtained. Bend tests indicated that the gas shielding provided good protection and that most welds exhibited good ductility. Welds took a 180 deg 3T bend in both longitudinal and transverse directions without failing. A departure from stainless steel handling methods





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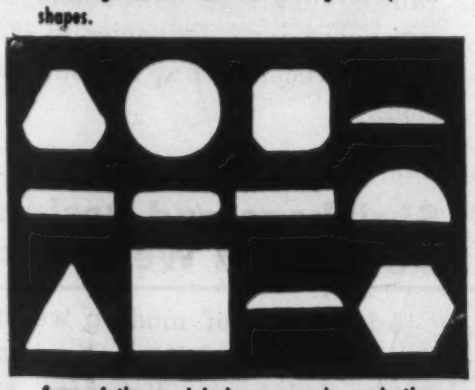

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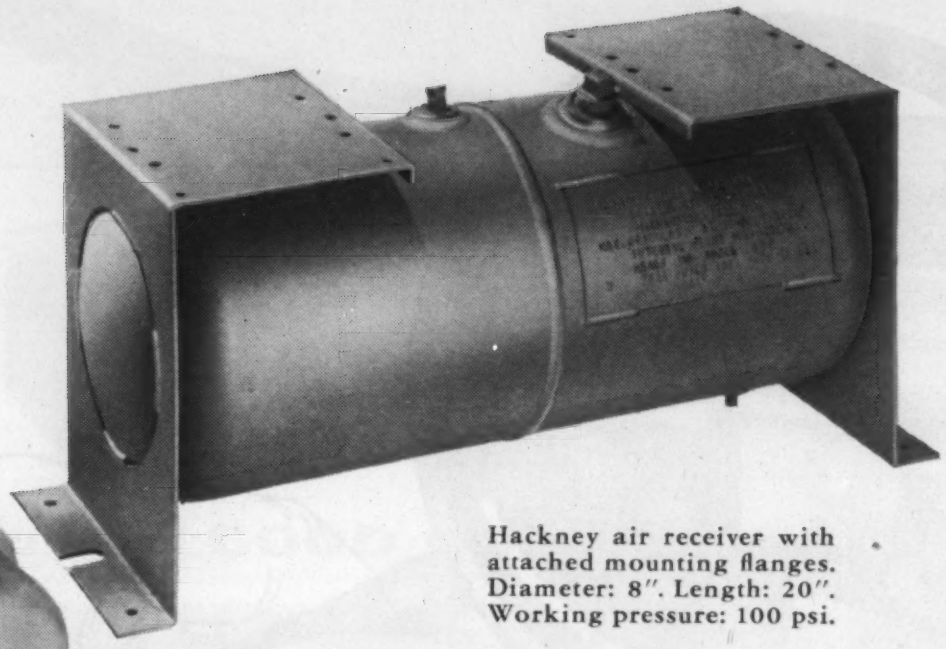
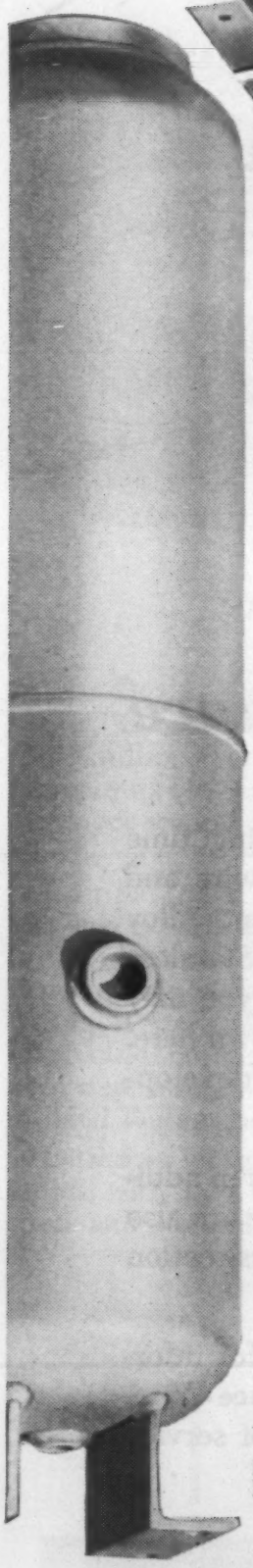


Hackney air receiver with attached mounting flanges. Diameter: 8". Length: 20". Working pressure: 100 psi.



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Contents Noted

results from the fact that with titanium, no shrinkage in welded cylinders occurs, and it is often necessary to shrink the welded part to mate it with others.

For resistance welding, good spot welds may be achieved with proper precleaning, relatively high electrode pressures and short weld times. Ryan developed complete certifications for a variety of gage combinations.

Riveting and dimpling

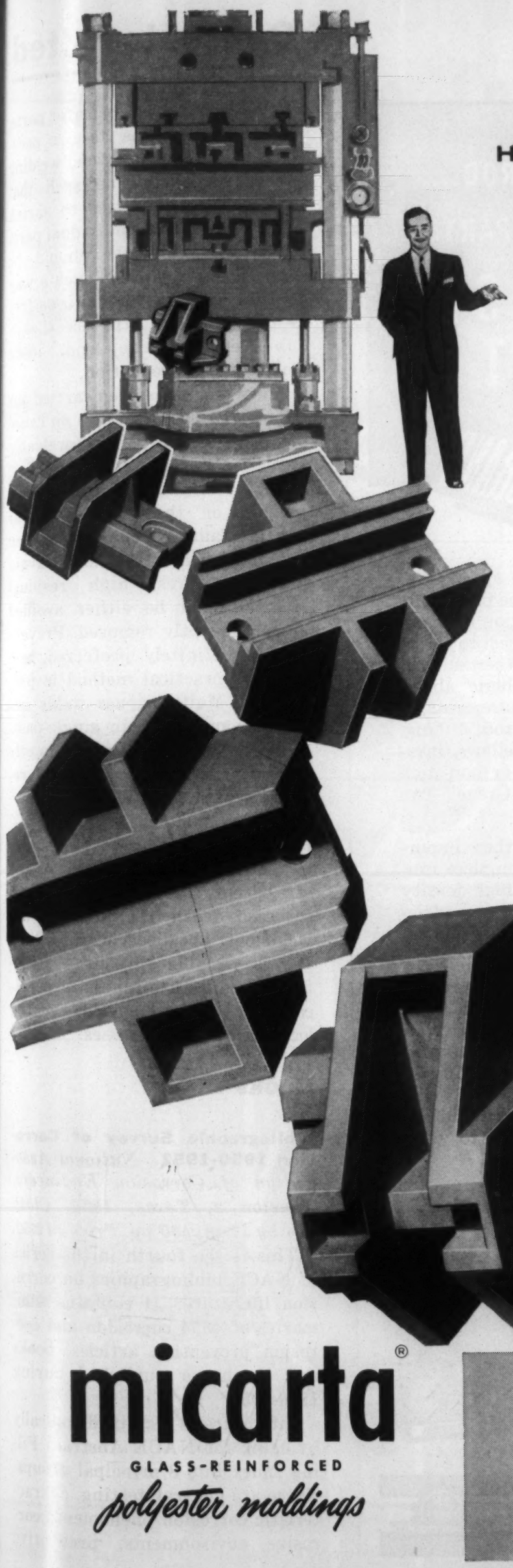
Good riveted joints were obtained with flush rivets and pressures up to 5000 lb, exerted over 1 sec. Good results were also obtained with ⅛-in button-head rivets that had been annealed for 20 min at 1300 F and driven with a force of 5100 lb. Successful experiments were carried out hot riveting ⅛-in. rivets in 0.072- and 0.018-in. sheet by placing the assembly in a spot welder.

Hot dimpling was carried out in 0.016-, 0.040-, 0.063-, and 0.080-in. sheet for rivet and screw diameters from 3/32 to ¼ in. According to Adams, dimpling of titanium offers no greater problems than does dimpling 7075-T aluminum, with the exception of increased forming temperatures, which should be within 600 to 700 F range. Satisfactory dimples can be made at lower temperatures, but inconsistencies in sheet stock preclude its recommendation.

Shrinkage and Residual Stresses in Weldments

Advantages of modern welding practice can be fully realized only when shrinkage, distortion and residual stresses are completely understood and mastered. In the April issue of *Schweissen und Schneiden* (German) R. Malisius discussed practical means of minimizing shrinkage effects in weldments and the cause of brittle fracture in weldable steels.

The larger and more complex a structure is, the more attention must be paid to heat effects dur-



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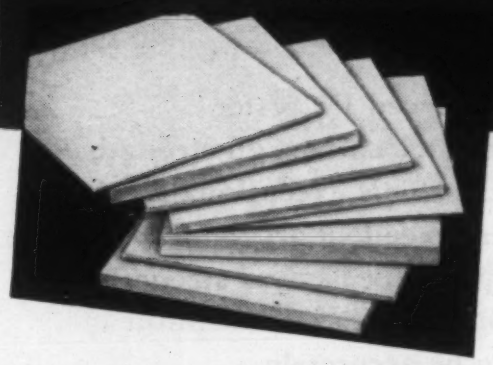

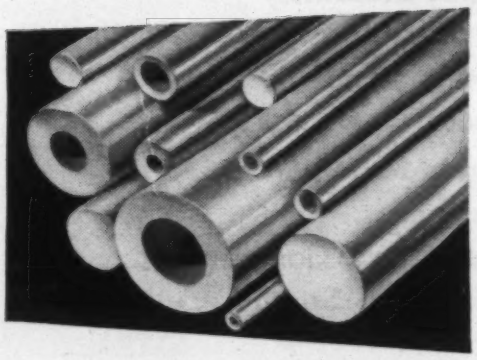

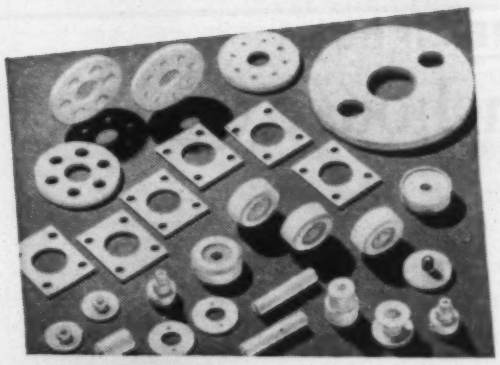

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Contents Noted

ing welding of prefabricated parts. Each structure has its own peculiarities, but in any case, welding procedures should be such that each part is permitted to shrink without restraint. Individual parts of large weldments should be planned and welded in such a way that the entire weldment is as free as possible from stresses. Use of sub-assemblies also lends itself well to mass production.

Much work has been carried out during the past 20 years on cause of brittle failures in weldable steels, but, according to Malisius, these investigations have not even touched on the main cause of brittle failure, namely uneven distribution of stresses. To avoid brittle failures, high residual stresses must be either avoided or subsequently removed. Prevention is definitely preferred, and the best practical method is preheating. Multiple pass welds are likewise preferred to single-pass.

The safest way of subsequently removing stresses is stress relieving, with 1100 to 1200 F generally recommended, though 570 to 750 F is adequate to remove danger of brittle failure. Cost of stress relieving is appreciable and increases with the size of the weldment. Localized stress relieving is feasible for large structures, but its usefulness is predicated on correct knowledge of the location of peak stresses.

Books . . .

Bibliographic Survey of Corrosion 1950-1951. *National Association of Corrosion Engineers, Houston 2, Texas, 1955. Cloth 8½ by 11 in. 430 pp. Price $12.50.*

This is the fourth in the series of NACE bibliographies on corrosion literature. It contains summaries of 4554 corrosion and corrosion prevention articles, books and brochures published during 1950-1951.

Literature is classified topically by using the NACE Abstract Filing Index into 8 principal groups. These are general, testing, characteristic corrosion phenomena, corrosive environments, preventive

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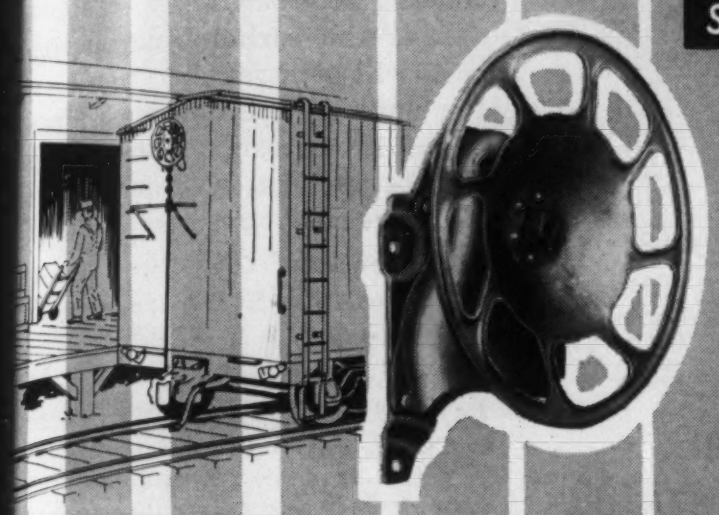

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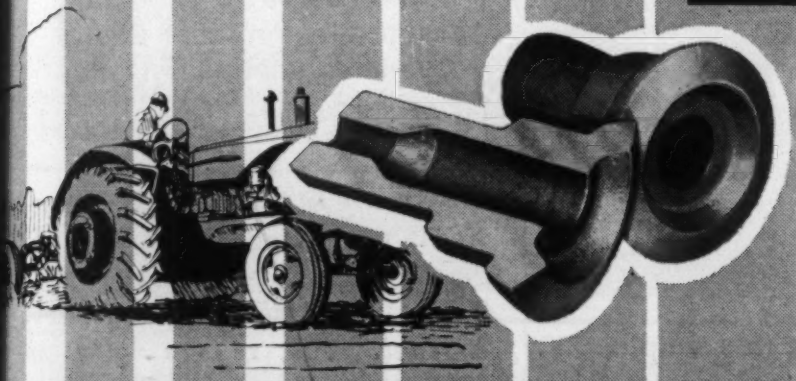

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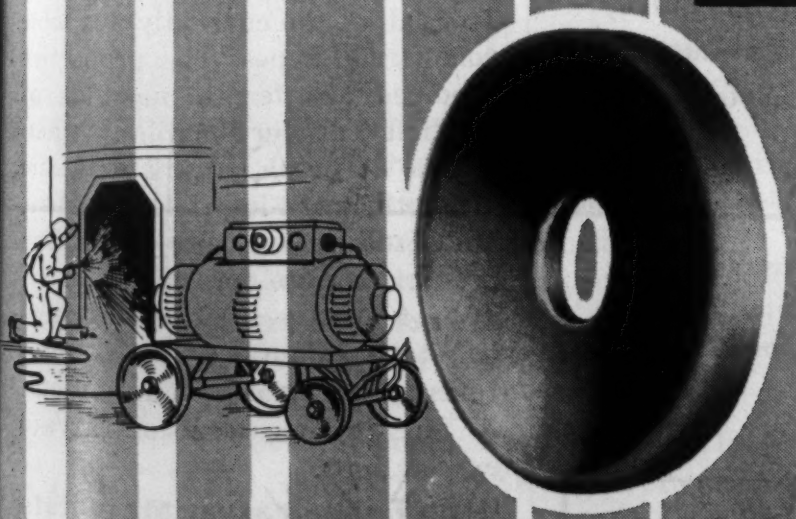

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Quality Control
INSTRUMENTS

Contents Noted

Books . . .

measures, materials of construction, equipment and industries. Subject and author indices are included.

Like the earlier volumes, this book will be a valuable time-saver for engineers and scientists engaged in corrosion investigations and the application of materials in corrosive environments.

Specifications for High Tensile and Low Alloy Steel Arc-Welding Electrodes. *American Welding Society, New York 18, N. Y. 1955. Paper 6 by 9 in. 14 pp. Price $.40.*

This improved and enlarged edition of a joint AWS-ASTM specification classifies the electrodes by chemical composition as well as by mechanical properties. It provides details on test methods, test requirements, standard sizes and lengths, packaging and marking. An appendix provides a guide to the understanding and best use of the specification.

Reports . . .

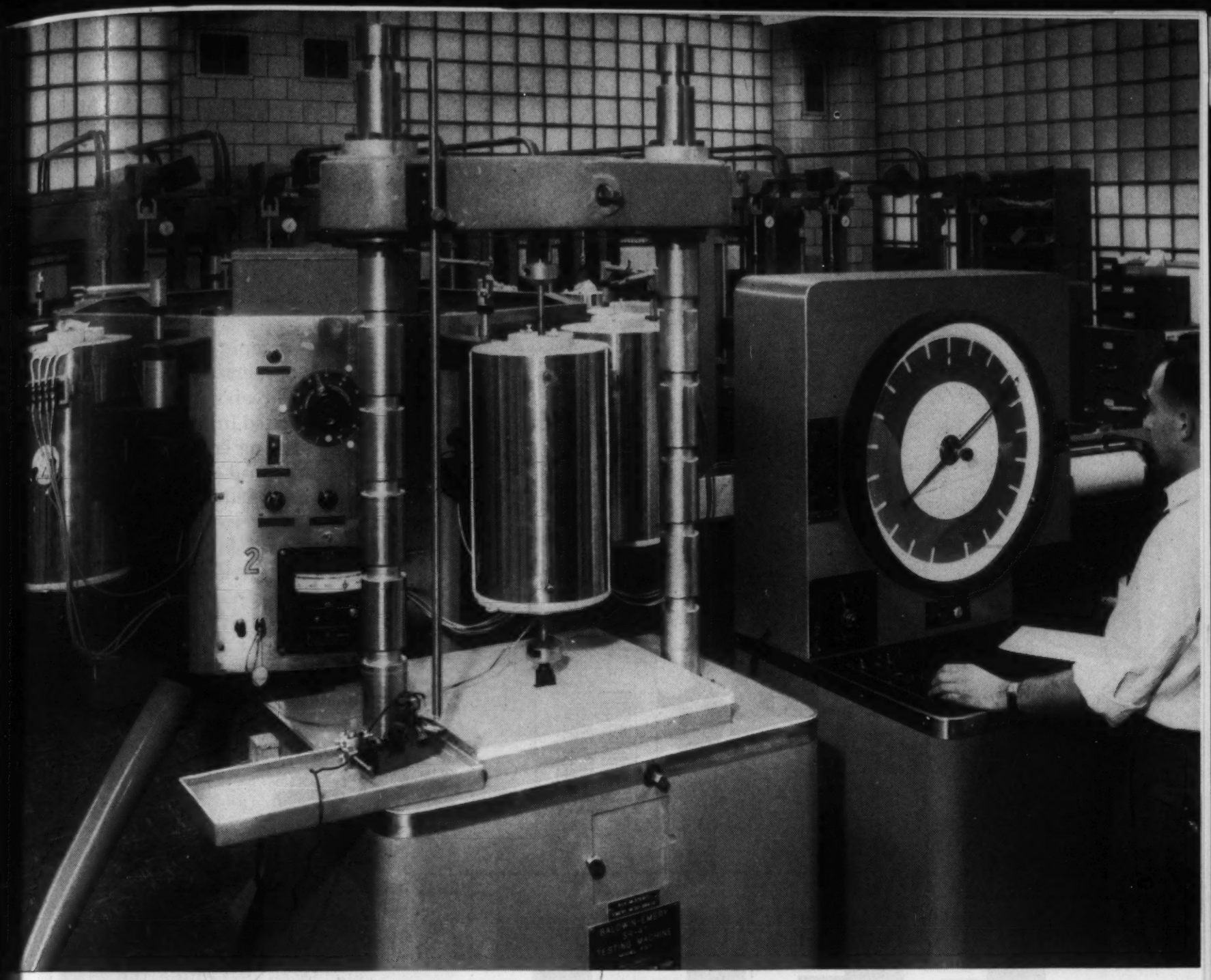
Plastics and Low Temperatures

Mechanical Properties of Rigid Plastics at Low Temperatures. *Henry A. Tisch. U. S. Picatinny Arsenal. PB 111579. 143 pp, photos, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $3.75.*

This report covers fifty-six different rigid plastics which comprise a representatve selection from all of the currently available commercial types. The properties reported are tensile modulus of elasticity, proportional limit, elongation at break, ultimate tensile strength, work-to-produce failure, and Izod impact strength. The properties were determined at 77, 10, —40, and —65F. Most results qualitatively agreed with expectations and previous investigations. A few results were contrary to expectations.

High Temperature Materials

Damping, Elasticity, and Fatigue Properties of Temperature-Resistant Materials. *B. J. Lazan and L. J. Demer, Syracuse University, N. Y. Nov. 1952. PB 116824. 42 pp, photo, drawing, diagram, graphs, tables. Available from*



New "all-electric" Baldwin SR-4® Testing Machine at Universal-Cyclops

measures electrically both tensional loads and strain on "SUPER ALLOYS" at 2200° F.

In the modern laboratory of Universal-Cyclops Steel Corporation, Bridgeville, Pa., "super alloys" for high temperature service are being tested at 2200° F. by a unique new Baldwin machine. Model FGT SR-4 is electrically powered and measures electrically both applied tensional loads and resulting specimen strain.

SR-4 load cells at the bases of the two columns sense loads up to 50,000 lb. in tension or compression. These cells control both the load indicating pointer and the recorder pen movement.

Strains of 0.160 in. diameter, 1-in. gage length buttonhead specimens, measured by a SR-4 type extensometer are transmitted electrically to the recorder. Close control of the strain rate is an important factor in these high temperature tests. The FGT's motor drive's loading control can be regulated to vary testing speeds from 0.025 to 9.0 in. per minute.

Univeral Cyclops is using an ingenious rotary jig to speed up greatly the frequency of tests at elevated temperatures. Eight electric furnaces on this jig heat test specimens simultaneously. Each is swung into testing position with a minimum of delay. This revolutionary new testing machine can give you automatic load reversal, creep tests, stress relaxation tests, shock tests as well as simple tension and compression. For complete detailed information please write today for Bulletin No. 4206. Address Department 2723, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

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TESTING HEADQUARTERS

BALDWIN-LIMA-HAMILTON

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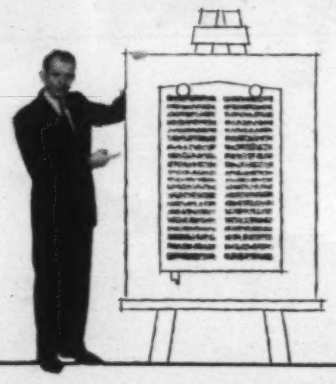

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are recommended for applications like dust shields, wipers, grease retaining washers, wicks and other uses where a high degree of resiliency is required.

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Contents Noted

Reports . . .

Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.75, Photocopy $6.50.

The damping elasticity and fatigue properties of several temperature-resistant materials were investigated in rotating cantilever-beam testing equipment. The room and elevated temperature tests were designed to reveal changes in damping energy and dynamic modulus of elasticity during constant cyclic stress fatigue tests at engineering stress levels.

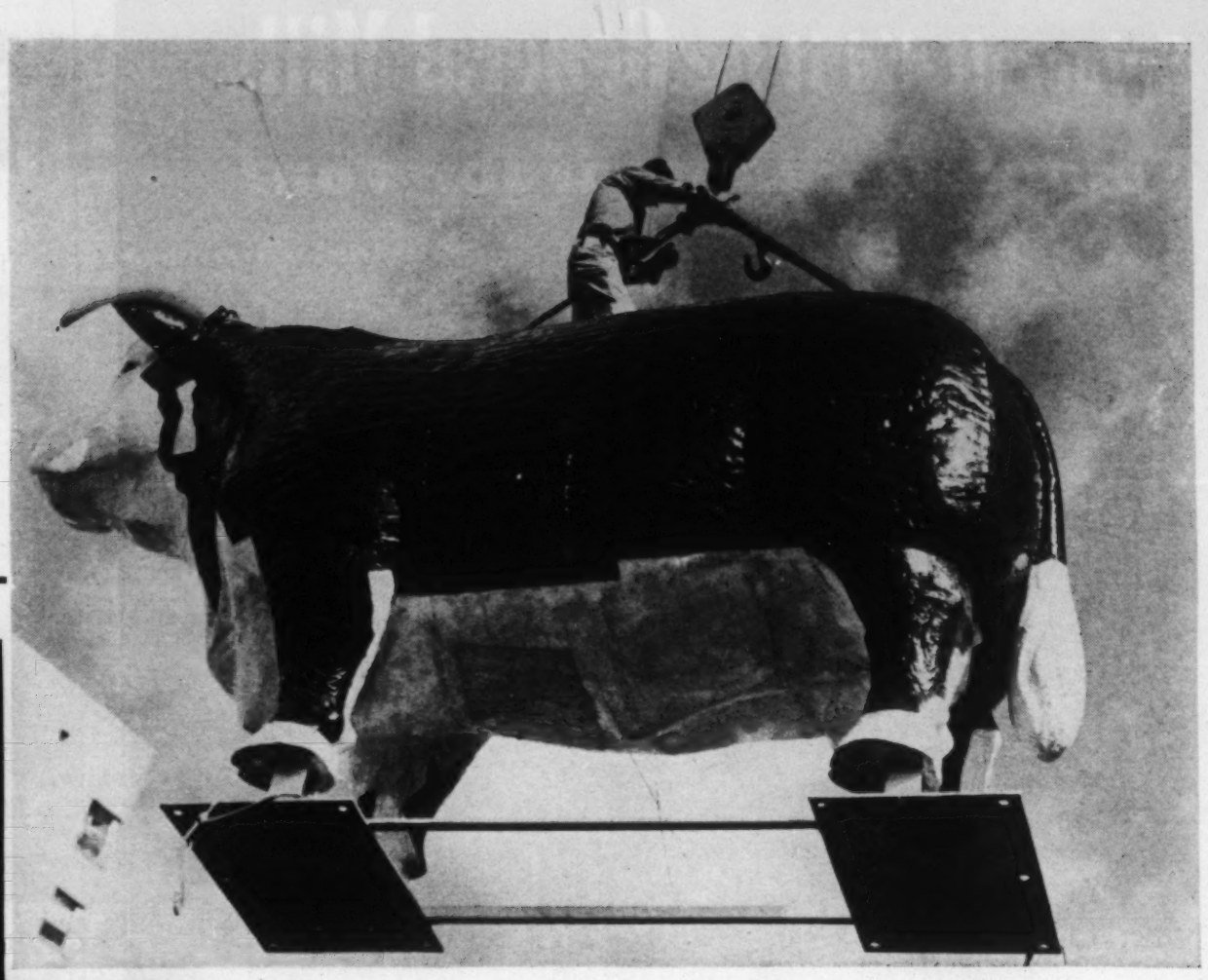
Fatigue and Aluminum Effect of Mean Stress on the Fatigue Life of Alclad 24S-T3 and Alclad 75S-T6 Aluminum Alloy. *I. Edward Wilks and Darnley M. Howard. U. S. National Bureau of Standards. Feb. 1953. PB 116821. 35 pp, photos, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.50, Photocopy $5.25.*

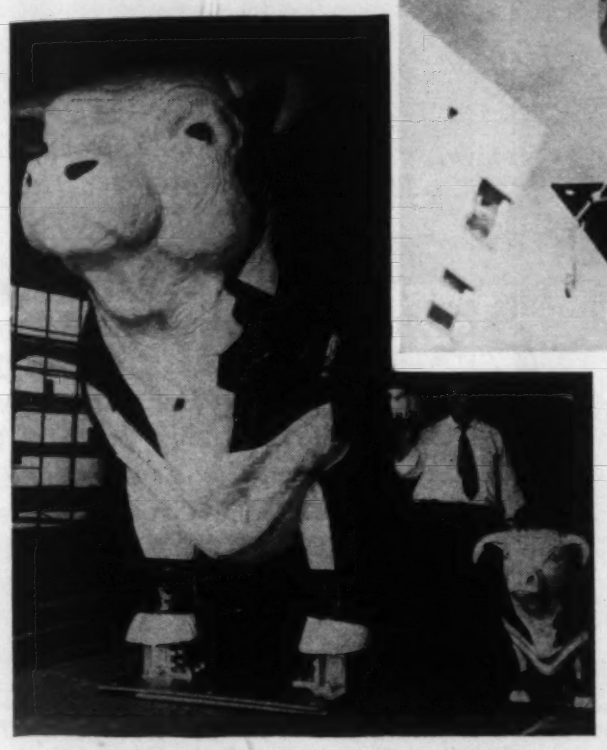
An investigation has been conducted to determine the effect of mean stress on the axial loading fatigue life of two alclad aluminum alloys in sheet form with stress concentrations. The alloys were 24S-T3 and 75S-T6. The specimens were rectangular, 0.8 in. wide and 6.5 in. long with a 0.125 in. diameter hole drilled at the center. Tests were conducted using a lever type machine.

Titanium Handbook on Titanium. *Heinrich K. Adenstedt. U. S. Air Force. Air Research and Development Command, Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio. Aug. 1954. PB 111631. 210 pp, photos, drawings, diagrams, graphs, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $3.00.*

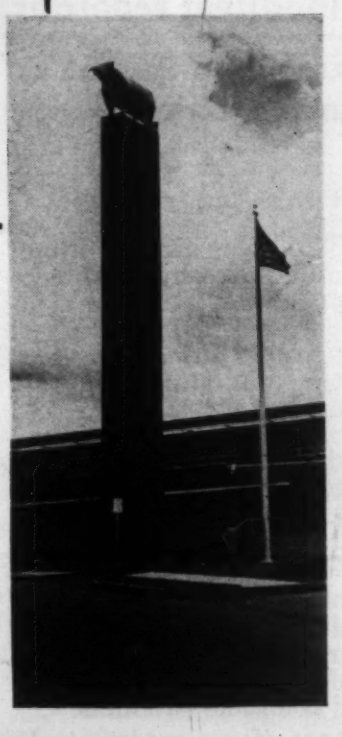
Information has been collected on specific properties and processing of titanium by literature survey and by personal contact with the proper persons and institu-

BIGELOW
Fiber Glass Products





Lew Edwards of Colonial Plastics Corp. holding the original plaster model, and standing between the 12-foot tall bull and its 3-foot prototype.



A little bull goes a long way . . .

From 6-inch high plaster model to 12-foot tall Bigelow Glass-Mat bull . . . from a plant in North Bergen, New Jersey to the top of a 90-foot pylon in Kansas City, Missouri . . . that's the saga of this pure-bred Hereford bull!

Simultaneous with its appearance atop the American Hereford Association building in Kansas City, this fantastic bull made its debut in a feature article in LIFE magazine, October 25th.

500 square feet of Bigelow Glass Mat went into the making of this fiber glass bull, bag molded by Colonial Plastics Corporation of Newark, New Jersey for Colonial Neon Co., Inc. of North Bergen, New Jersey.

Colonial chose Bigelow 4-ounce FORMAT* for this unusual job because of its outstanding ability to conform readily to intricate curves and details.

* A Bigelow Trademark

BIGELOW FIBER GLASS PRODUCTS CAN SOLVE YOUR PROBLEMS, TOO!

FORMAT* is just one of Bigelow's versatile reinforcing materials. Bigelow has a complete line of products for matched metal die and all types of molding. For further information, fill out this coupon.

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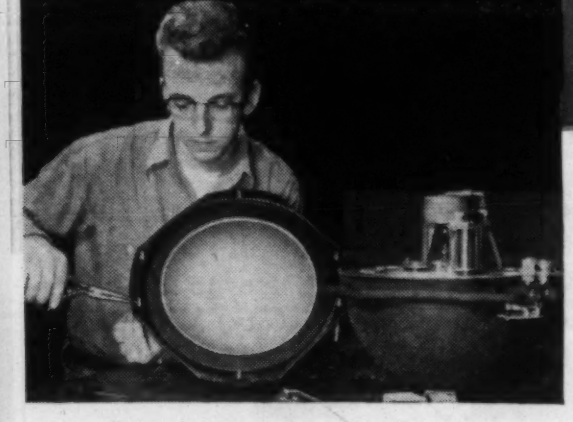
Spincraft did it for General Mills

Spincraft can do it for you!



Spun spheres protect mechanical fingers of world's toughest recorder

another example of Spincraft's "start-to-finish" fabrication

15 Different Operations —

The sphere, protecting the delicate sensing instruments, is completely fabricated by Spincraft. The sphere consists of an outer steel and inner aluminum shell separated by insulating material. The two hemispheres are joined together by an ingenious locking and sealing arrangement. Spincraft's complete fabricating responsibility involved spinning, machining, arc-welding, spot welding, brazing, grinding, sawing, drilling, braking, stamping, phosphate plating, anodizing, painting, assembly and pressure testing. Craftsman (above) is shown assembling a Flight Recorder.

This aircraft Flight Recorder, manufactured by the Mechanical Division of General Mills, etches a continuous 300-hour record of heading, air speed, vertical acceleration and altitude on aluminum foil. Each Recorder is fully-enclosed and protected in a specially fabricated sphere — made by Spincraft. The recording device, when enclosed in the sphere, is designed to withstand shocks of 100G's and resist temperatures of 2000°F up to 30 minutes.

This is another example of Spincraft's versatility and manufacturing skill. We offer complete facilities for contract manufacture of finished parts, assemblies and complete products.

Take advantage of our modern tools for spinning, deep drawing and stamping as well as complete fabrication. They can pay off in savings for you.

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Contents Noted

Reports . . .

tions. The data have been evaluated and are condensed in this report. The three major sections of titanium technology covered are: production, physical metallurgy and properties.

Minutes of Titanium Symposium on Diffusion and Mechanical Behavior, Held at Columbia University. *New York, N. Y., June 9-10, 1954. U. S. Ordnance Dept. Metallurgy Advisory Committee on Titanium. 1954. PB 111567. 59 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $1.50.*

Selected Contents: Fatigue Characteristics of Titanium and Titanium Alloy Rod at —40 F, Room Temperature, and 600 F. —*A.L. Blank and J.H. Port;* Basic Study of The Behavior of Titanium Alloys Under Repeated Load. —*E. D'Appolonia;* Effect of Strain Rate on The Creep and Tensile Performance of Titanium Alloys. —*D. R. Luster, W. W. Wentz, and J. P. Catlin;* Intermediate Temperature Creep and Rupture Behavior of Titanium and Titanium Alloys.—*J. W. Freeman, J. V. Gluck, and H. M. Burte;* Creep Rupture Behavior of Titanium and Two of Its Alloys at High Temperatures. —*L. S. Richardson and N. J. Grant;* Tensile and Impact Properties of Ti-75A Over a Range of Temperatures.—*L. Sama and A. Opinsky;* Effect of Strain Rate, Temperature, Notches and Hydrogen Content on the Mechanical Properties of High-Purity and Commercial-Purity Titanium and RC-130A Alloy.—*G. A. Lenning, C. M. Craighead, and R. I. Jaffe;* High Strength Titanium Alloys of Good Ductility and Toughness.—*S. Abkowitz;* Summary.—*L. D. Jaffe.*

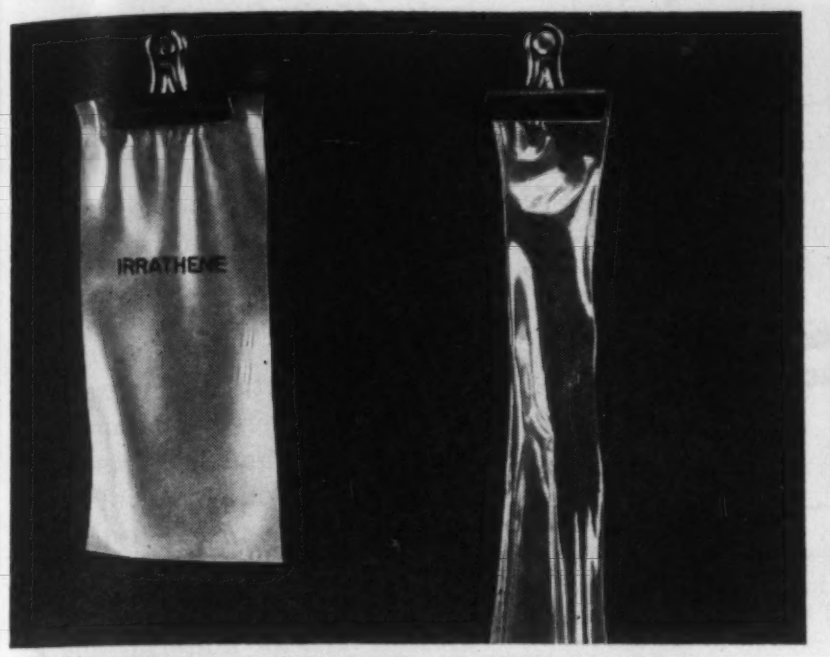
High Temperature Alloy Investigation of Axial Loading Fatigue Properties of Heat-Resistant Alloy N-155. University of Minnesota, Minnneapolis, Minn. *Contract No. AF 33(038)-18903. Order separate parts described below from Library of Congress,*

◀ For more information, Circle No. 378

WHERE CAN YOU USE THIS

NEW PLASTIC MATERIAL*

WITH THESE PROPERTIES?



WITHSTANDS TEMPERATURES AS HIGH AS 200°C . . .

. . . for limited time; continuous temperature limits range from 105°C to 125°C. The two sheets of film above were exposed to temperatures of 150°C for 5 minutes; the G-E Irrathene *irradiated* polyethylene film on the left does not melt, while the ordinary polyethylene on the right has melted and flowed to twice its original length.

RESISTS STRESS CRACKING

The G-E irradiation process eliminates environmental stress cracking—an important problem in polyethylene cable, for example. Here two .125″ pieces were bent sharply in a detergent solution to induce environmental stress cracking. Ordinary polyethylene (right) fails completely, whereas Irrathene has not even begun to craze.

SHRINKABLE GRADES FOR ENCAPSULATION

G-E Irrathene tape, grade 210, can be wound on irregular shapes such as electrical coils, pipe fittings, etc., then heated and shrunk around the object and over the ends to provide a tight, form-fitting, thermally sealed encapsulating layer.

MOISTURE AND CHEMICAL RESISTANCE

Irrathene tape and film is virtually impervious to moisture, including direct immersion. And, being chemically inert, it successfully resists most ordinary chemicals.

* IRRATHENE
IRRADIATED
POLYETHYLENE

Along with the special properties described above, G-E Irrathene irradiated polyethylene also retains all the outstanding properties of regular polyethylene, including excellent dielectric characteristics. To help you apply G-E Irrathene in your product or process, we have prepared a special technical report; why not write today for your copy and an evaluation sample to: Sect. 504-3, Chemical & Metallurgical Division, General Electric Company, Pittsfield, Mass.

Progress Is Our Most Important Product

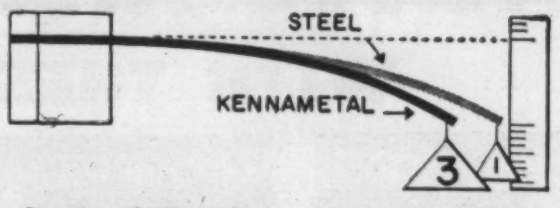
GENERAL ELECTRIC

For more information, turn to Reader Service Card, Circle No. 420

Here's an important message for Y·O·U· about Y·M·E·

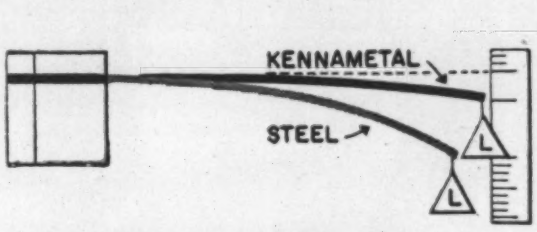
YME—Young's Modulus of Elasticity—is one of the most important characteristics of any metal used in structural components of machines used for precision work. It determines the extent to which those parts will deform under a given load.

• • •



Same deflection—greater load

Put another way, the high YME of Kennametal means that you can load Kennametal parts about three times as much as similar parts made of steel . . . an important factor in precision work.



Same load—less deflection

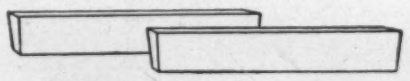
No substance is without deformation under load, but Kennametal* deflects less than 40% as much as the hardest steel, because the YME of Kennametal is near 90 million psi while that of steel is approximately 30 million.

Same deflection—same load —less material

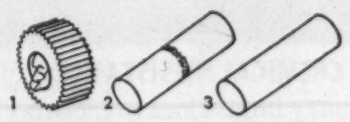
Or, if deflection and loading are acceptable, a Kennametal part will require less material. Thus, machine elements may be miniaturized—with an attendant increase in economy, compactness and convenience.

. . . here's how designers have interpreted the YME of KENNAMETAL* to their problems

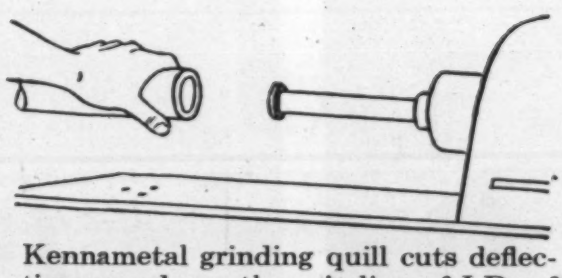
The following are a few instances where designers solved production problems with Kennametal because its high YME, plus its high density, minimizes deflection, chatter, weaving, wear and dampens vibration.



An automotive manufacturer, for example, switched to solid Kennametal for grooving tool blades used in cutting piston ring grooves in aluminum alloy pistons . . . jumped cuttings between resharpenings from 800 to 18,000 pistons. Apparently, the longer wear resulted from the elimination of weaving due to Kennametal's high YME.



Kennametal pins for knurling tools showed no wear or deformation (fig. 3) under increased production speeds and feeds, which shattered the steel pins generally used (fig. 2); steel pin imbedded in knurl, (fig. 1).

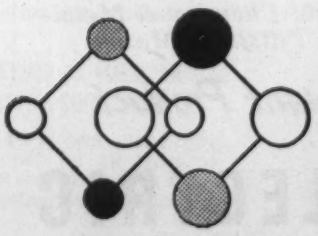


Kennametal grinding quill cuts deflection, speeds up the grinding of I.D. of cylinder liner for plastics compressor, and provides greater accuracy of machining.

Perhaps the answer to your "idea problem" is here, too

This characteristic high YME of Kennametal, in addition to its extreme hardness, high strength and resistance to corrosion and abrasion, is being utilized to great advantage in a variety of applications. Perhaps it can be the means of getting YOUR idea into production. Why not send for additional information? Write to KENNAMETAL INC., Latrobe, Pennsylvania.

**Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.* 5537



INDUSTRY AND
KENNAMETAL
. . . Partners in Progress

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Contents Noted

Reports . . .

Publication Board Project, Washington 25, D. C., giving PB number of each part ordered.

Part 1. B. J. Lazan and F. De Money. Mar. 1953. PB 116827. 23 pp, diagrams, graphs, table. Microfilm $2.25, Photocopy $4.00.

Dynamic creep and rupture data are presented on N-155 at room temperature and 1000 F., correlated to some extent with prior work. Temperature increases were observed in certain temperature and stress ranges immediately after the application of alternating stress to a test specimen. These are discussed in terms of the internal damping capacity of the material and the possibility of utilizing these observed temperature increases as a qualitative indication of damping is suggested.

Part 2. Exploratory Investigation of The Effect of Temperature, Time, and Stress on Fracture Characteristics and Metallographic Structure of N-155 and Hardness of N-155 and S-816. *Fred W. De Money. Feb. 1953. PB 116828. 42 pp, photos, graphs, table. Microfilm $2.75, Photocopy $6.50.*

An exploratory study of effect of the test variables on the macroscopic appearance of the fracture surface was continued. Fracture profiles were investigated microscopically and an attempt made to quantitatively analyze the nature of the fracture profile. From this analysis is shown that the tendency for an intercrystalline fracture to occur decreases with increasing stress ratio. Investigation of the metallograpic structure and hardness of unstressed N-155 verifies prior work concerning the precipitation hardening characteristics of this material.

High Temperature Fatigue Properties of Temperature-Resistant Materials Under Tensile and Compressive Fatigue Stress. *B. J. Lazan and E. Westberg. Syracuse University, Syracuse, N. Y. Nov. 1952. PB 116823. 45 pp, photo,*

Remington Rand

BETTER BUSINESS METHODS

For Greater Profits Through Lower Costs

NOW—Still More Effective Machine Loading With New, Simplified Sched-U-Graph System

Profit-conscious manufacturers have long recognized the value of an effective system of machine loading. They have also long recognized that the *most effective* system of machine loading is based on the Remington Rand Sched-U-Graph.

Now, a new, simplified Sched-U-Graph System gives you more accurate and precise machine loading than ever before. With this new system your machine loading will be divided easily into two phases: *Rough Machine Loading*, for scheduling operations as far into the future as is deemed practical; *Fine Machine Loading*, for scheduling in minute detail those operations to be undertaken in the next two weeks.

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In short, the Remington Rand Machine Loading System solves the problem of how to get *the greatest possible production return for each dollar you invest in machines, men, and facilities.* At a glance, this system, utilizing visible charting, tells you the load ahead of each machine, work station, or machine center... the jobs that constitute that load... all scheduled starting and completion dates... how much free machine time is available, and when it is available. All the benefits and methods of the new Remington Rand Rough & Fine Machine Loading System are explained fully in our new free folder. Write today for KD738.

Cut Production Costs With Closer Inventory Control

The absence of complete control of manufacturing inventory results in needless wastes of time, labor, money, and facilities. You can eliminate these wastes by switching now to the Remington Rand System of Inventory Control for Manufacturers.

Profit-eating overstocks mean increased investment and expense, more space for storage, deterioration and obsolescence. Understocks mean lost sales and extra expense for "rush" orders and emergency buying.

For your guidance, Remington Rand offers a new illustrated booklet, "Inventory Control For Manufacturers," which contains all the most modern and effective techniques for controlling inventory and thereby reducing investment in material and clerical record-keeping costs. Circle KD406.

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1-26

Profit-Building **IDEAS** For Business

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During the last fifty years, the Hotpoint Company has pioneered in the development of the electric range to its present highly refined state. Naturally, dependable regulation of oven temperatures is essential to efficient operation. Therefore, the Hotpoint range depends upon Chace Thermostatic Bimetal as an integral part of the temperature controlling thermostat.

The Hotpoint thermostat functions to control oven heat by two means: an oven-mounted sensing bulb reacts to a preset temperature by the expansion of contained fluids which impart a force on the expansible and contractible bellows assembly (A), and on the operating blade (B), to break the circuit of the double pole contacts (C), with a snap-action.

Since much of the fluid contained within the bellows assembly is *exterior* to the oven and subject to the expansion and contraction effects of extraneous temperatures, Chace Thermostatic Bimetal (D) is employed in a section of the operating blade to function as an automatic compensator for eliminating the effects of undesired temperature sensing. Its flexing adds to or subtracts from the forces of curvature of the operating blade depending upon whether the temperature is below or above the design base—average room temperature.

Prolonged oven operation will cause a temperature build-up in the range backsplasher (as high as 200° F.) so that the range, if not provided with a compensating Chace Thermostatic Bimetal element, would supply temperatures some 120° F. lower than desired.

Write now for our free booklet containing design and application data for the 29 different types of Chace Thermostatic Bimetal.

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, Circle No. 404

Contents Noted

Reports . . .

drawings, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $2.75, Photocopy $6.50.

Newly developed grips and machine improvements are described for fatigue loading under direct stress (tension-compression) ratios of alternating to mean stress from zero to infinity. Data are presented to indicate the uniformity of stress distribution possible with these grips and accuracy of the average stress. Dynamic creep, rupture and ductility data are reported on N-155, S-590 and Vitallium at 1350 F and 1500 F, under direct stress combinations from static to reversed loading.

Magnets Soft Magnetic Materials. *Ninth quarterly progress report, under Contract No. W-36-039-sc-38243 covering period Mar. 1, 1951 to May 31, 1951, by J. P. Martin. Allegheny Ludlum Steel Corp., Brackenridge, Pa. June 1951. PB 116831. 51 pp, graphs, tables. Available from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $3.00, Photocopy $7.75.*

The investigation of 2 mil strip cold rolled 98% includes results on the effect of temperature on the recrystallization in a magnetic field as determined by D. C. hysteresis loops and magnetization curves. The effects of heat treatment and metallurgical history on the expansion, critical temperatures and specific gravity of various alloys of cobalt iron from 36-74% cobalt are described. Data on the anomalous results of A.C. core loss measurements of Deltamax annealed in a magnetic field are reported and discussed.

High Temperature Creep Some Fundamental Experiments on High Temperature Creep. *John E. Dorn. University of California, Institute of Engineering Research. Minerals Research Laboratory, Berkeley, Calif. Apr. 1954. PB 116837. 63 pp, photos, graphs, tables. Avail-*

UNICHROME
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Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

Chromating of zinc gives a desirable finish

Sprayable plastisol gives smooth coating 20 mils thick or thicker

Large equipment can now be protected with vinyl plastisols. Application limitations have been overcome by a plastisol compound developed by United Chromium. Unichrome Coating 5300 makes the *spraying* of plastisol protection a practical and easy matter. No longer need the advantages of these heavy duty materials be restricted to objects of dippable size.

Unichrome Coating 5300 builds a protective film up to 20 mils thick in one coat. This is at least 5 to 20 times the thickness of ordinary coatings. Multiple coats can do many of the jobs for which plastic and rubber sheet materials are generally used. With Coating 5300, protection is free from pores or seams.

UNIQUE PROPERTIES

Plastisols are viscous vinyl liquids that take on a rubbery look and feel when baked at 350° to 365°F. They form chip-proof coatings with exceptional toughness and high dielectric strength. Since Coating 5300 is a vinyl material, it withstands acids, alkalies, salt solutions and a host of other chemicals and corrosives that attack ordinary coatings and the underlying metal.

OTHER PLASTISOL COMPOUNDS

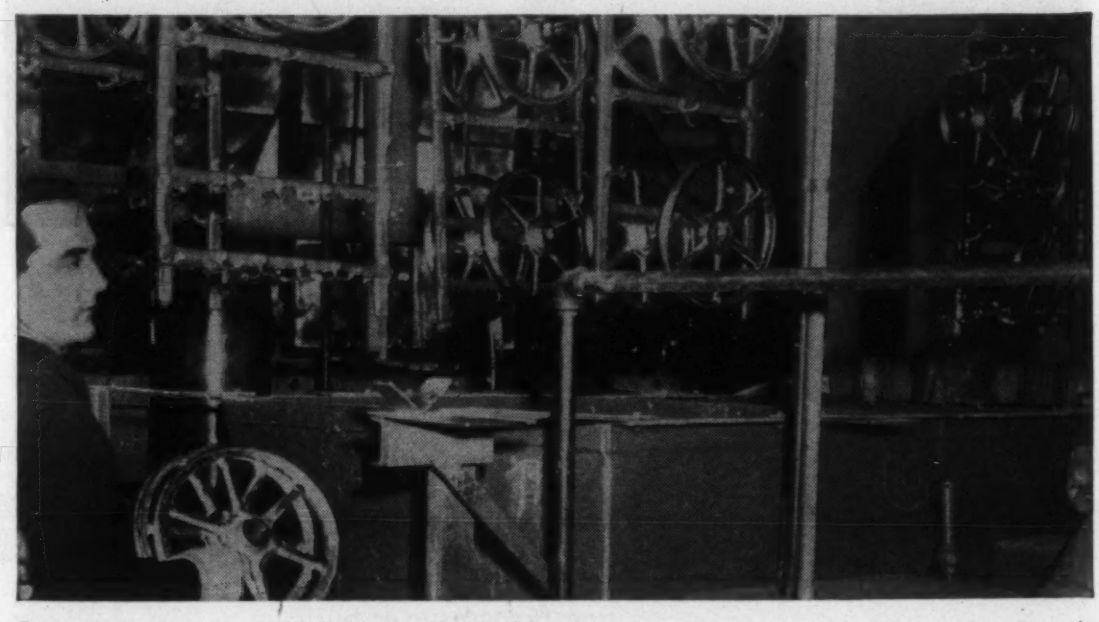
For other methods of application such as dipping, electrostatic spraying, or roller coating, Unichrome Series 4000 Plastisols offer coatings controllable in thickness from 3 mils to 3/16-inch. From the hundreds of formulations available, almost any requirement in plastisols can be met.

More information on the features of plastisols outlined in Bulletin VP-1. Send for it.

UNITED CHROMIUM DIVISION
METAL & THERMIT CORPORATION

100 East 42nd Street, New York 17, N. Y.
Waterbury 20, Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.

Protection, economy and good quality achieved through use of Unichrome Dip



Economical, clear chromate finishing is being assured at the plant shown here because the chromate dip is matched both to the product and to the method of operation.

By chromate treating zinc, various finishes can be produced, including chromium-like clear, iridescent yellow, gold, brass, olive drab and black colors. But there's more to these finishes than meets the eye.

There's greatly increased corrosion resistance for zinc plated steel or zinc die castings. There's also the ease with which the finishes are produced; the low cost per sq. ft. of area treated; the fine paint-base they form. In short, chromate finishing offers both a quality finish and an economical one.

MATCH PROCESS TO PRODUCT

In operation, the chromate solution not only creates a corrosion resistant finish, but it also strips away some of the finish just formed. This chemical activity determines thickness of the chromate finish, and therefore its corrosion resistance. It governs color and eye appeal, as well.

Composition of the chromate solution, and time it acts on the zinc affect results. Even intricacies in shape of the product can affect uniformity of the finish.

RIGHT SOLUTION—RIGHT FINISH

The problem then is to get the one right chromate dip solution for the operation — the one that matches the needs of the product and the production setup and thereby assures satisfactory results and simple, trouble-free operation.

United Chromium is a good source to contact for chromate finishes. The unusually wide line of Unichrome Dips permits excellent matching to satisfy all the requirements — corrosion resistance, eye appeal, color, type of production equipment used, and specifications which must be met.

Write for specification chart giving details on Unichrome Dips for all chromate treating operations.

For more information, turn to Reader Service Card, Circle No. 431

GAS ATMOSPHERES' NITROGEN GENERATOR PRODUCES GAS FOR WORLD'S LARGEST BELL TYPE FURNACES . .

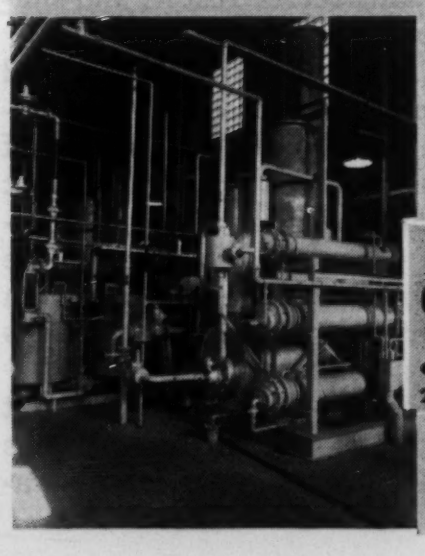
To increase furnace payload and yet retain perfect atmosphere protection one of the nation's foremost producers of rod and wire recently set into operation the three largest diameter bell type annealing furnaces ever built.

These furnaces — designed and built by the Lee Wilson Engineering Co., Inc., are a full 108" in charge diameter, capable of annealing three stacks of 48" diameter rod coils.

To make certain of getting a dependable supply of nitrogen Lee Wilson engineers equipped the installation with a 4000 c.f.h. Gas Atmospheres Nitrogen Generator.

Gas Atmospheres' engineers know metals and metal annealing. In fact, the nation over, wherever you find modern, efficient annealing, chances are the gas generation equipment was designed and built by Gas Atmospheres.

So, if you're thinking of annealing under a protective atmosphere, or your present generation equipment gives you cause for concern, why not call in a Gas Atmospheres' field engineer? He'll be glad to talk over your requirements with no obligation.



gas Atmospheres, inc
equipment for producing industrial gases
20011 WEST LAKE ROAD CLEVELAND 16, OHIO

Neat, compact 4000 c.f.h. Gas Atmospheres Nitrogen Generator that supplies all the gas required to run three large furnaces described above.

For more information, turn to Reader Service Card. Circle No. 408

Contents Noted

Reports . . .

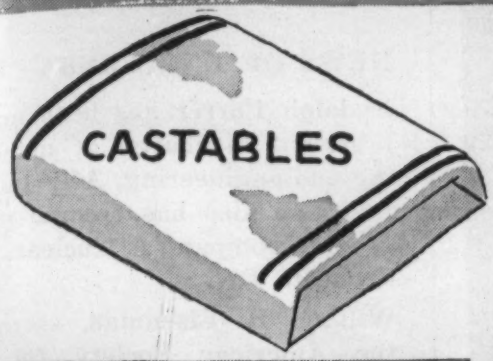
able from Library of Congress, Publication Board Project, Washington 25, D. C. Microfilm $3.25, Photocopy $9.00.

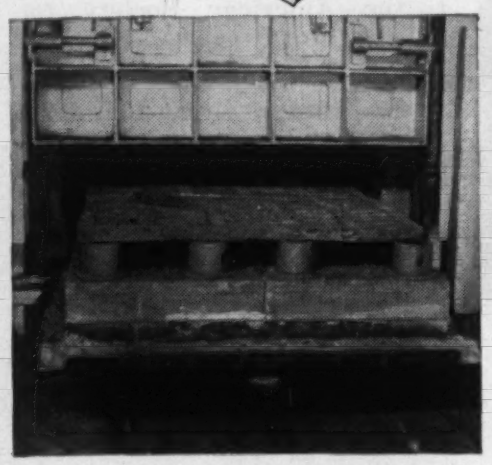
At high temperatures, the creep strain Σ, appears to be a function of a temperature (T) compensated time (t) namely $t\theta$—$\Delta H/RT$, and the stress. X-ray analyses and plastic properties reveal that the same structures are developed at the same values of $t\theta$—$\Delta H/RT$ following creep at the same stress. Contract N7-onr-295, Task order II, NR-031-048, 35th technical report. Prepared for presentation at the International Conference on Creep and Fracture of Metals at High Temperatures, held under the auspices of the National Physical Laboratory in Teddington, Middlesex, May 31 to June 2, 1954.

Aluminum Plate at High Temperatures Preliminary Investigation of The Compressive Strength and Creep Lifetime of 2024-T3 (formerly 24S-T3) Aluminum Alloy Plates at Elevated Temperatures. *Eldon E. Mathauser and William D. Deveikis. June 1955. (NACA RM L55E11b). 12 pp, diagrams. Available from National Advisory Committee for Aeronautics, 1512 "H" St., N.W. Washington, D. C.*

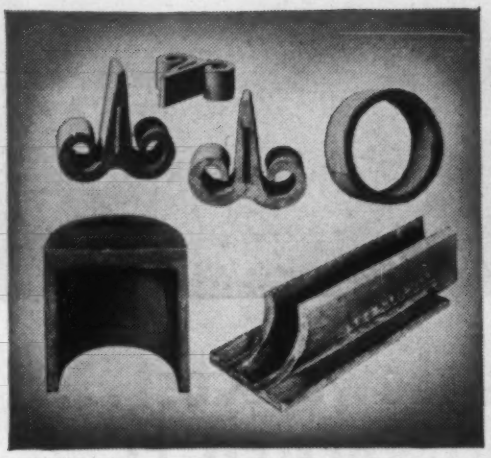
The results of elevated-temperature compressive strength and creep tests of 2024-T3 (formerly 24S-T3) aluminum-alloy plates supported in V-grooves are presented. A relation previously developed for predicting plate compressive strength at room temperature was satisfactory for determining elevated temperature strength. Creep-lifetime results are presented for the plates in the form of master creep-lifetime curves using a time temperature parameter. A comparison is made between tensile and compressive creep lifetime for the plates, and the magnitude by which the design stress is decreased because of material creep and loss of strength due to exposure at elevated temperatures is indicated.

Here's the most convenient way to make Refractory Concrete:

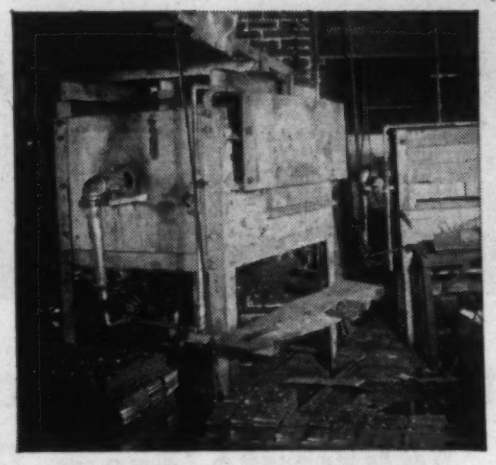




★ CAR TOPS
★ ARCHES ★ HEARTHS



★ SPECIAL SHAPES
★ CORE OVEN FLOORS



★ HEAT TREATING FURNACES
★ DOOR LININGS

IT'S THAT SIMPLE—Castable Refractories completely eliminate the need of finding suitable aggregates . . . and grading them to the right sizes. Packaged Castables come to you with Lumnite* calcium-aluminate cement and selected aggregates already mixed—needing only addition of water. The resulting Refractory Concrete reaches service strength in 24 hours or less.

This convenient way of making Refractory Concrete speeds work and cuts labor costs. It simplifies tough jobs—and some Castables are suitable for use at temperatures of 3000°F. or higher.

REFRACTORY CONCRETE made with Castables is the *adaptable* refractory. Easy to place in any size or shape.

No cutting or fitting necessary when you pour furnace walls, door linings and special shapes. There's no volume change to bother about. Build heat resistant floors, furnace walls, arches and hearths—Refractory Concrete withstands severe thermal shock, resists spalling.

In fact, you'll find Castables tailor-made for speed and convenience on many Refractory Concrete jobs. Handy for repairs, too.

CASTABLES to meet specific temperature and *insulation* requirements are made and distributed by leading manufacturers of refractories. For further information, write to LUMNITE BUREAU, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, New York.

*"*LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

MM-L-54

ATLAS®

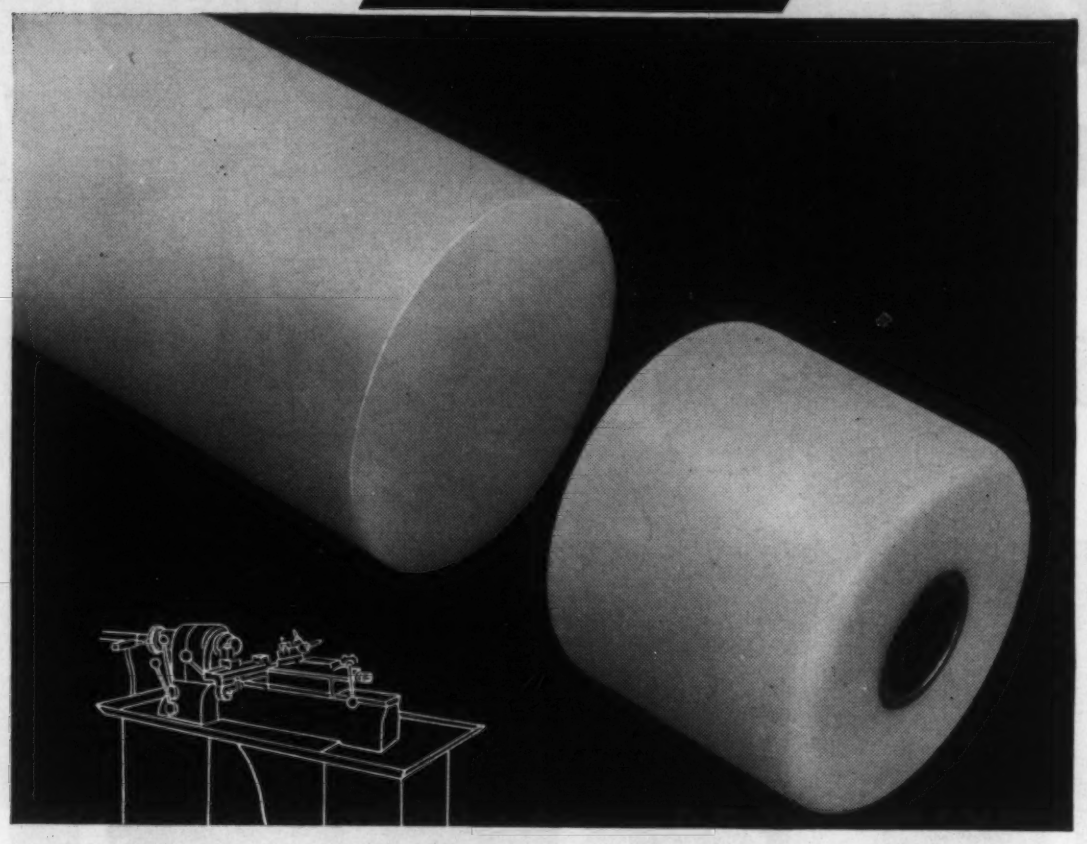
LUMNITE for INDUSTRIAL CONCRETES

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

UNITED STATES STEEL HOUR—Televised alternate weeks—See your newspaper for time and station

For more information, turn to Reader Service Card, Circle No. 433

POLYPENCO® NYLON SHAPES



Quality Nylon Parts at Lower Cost... *Fabricate* From POLYPENCO Shapes

● Take the uniform high quality of POLYPENCO Nylon Shapes . . . add fast, economical machining on your standard metalworking equipment . . . and you have an unbeatable combination giving you highest quality nylon parts at low cost. Here's why:

- Better performance starts with better quality: POLYPENCO Nylon Shapes are manufactured under rigid controls to assure absolute uniformity in every piece, every order.
- POLYPENCO Nylon is supplied in standard shapes of rod, strip, tubing, tubular bar and slab. On standard metalworking tools you fabricate your own parts—rapidly, economically.
- You save costs of molding dies, get greater design flexibility, fabricate to close tolerances. Machining is easy, requires no special operator training or skill.
- No costly delays in your production schedules . . . POLYPENCO Nylon Shapes are carried in stock, available for immediate delivery in stock sizes.

Technical bulletins and prices mailed promptly in answer to your request.

When Parts Call for Nylon Specify POLYPENCO!

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POLYPENCO nylon, teflon* and other non-metallics

*DU PONT TRADEMARK

For more information, turn to Reader Service Card, Circle No. 439

news of ENGINEERS COMPANIES SOCIETIES

NEWS OF ENGINEERS

Rudolph Furrer has been made vice president in charge of manufacturing and engineering, ACF Industries, Inc., and also has become president of the company's Nuclear Energy Products Div.

William H. Eisenman, secretary of the American Society for Metals since 1918, has been named an honorary member of the Iron & Steel Institute of Great Britain.

Vernon R. Degner has joined Barry Controls Inc. as a section engineer.

Dr. Joseph J. Coleman has been promoted to vice president of engineering, Burgess Battery Co.

Charles W. Mote has been appointed plant manager of the Dodge Forge Plant, Dodge Div., Chrysler Corp.

Jack L. Bowers, Jack Mason and **Dr. Marvin Stern** have been appointed to the staff of the vice president of engineering, Convair Div., General Dynamics Corp.

C. S. Walton, formerly staff metallurgist, Crucible Steel Co., has been named chief metallurgist at the company's Midland, Pa., works.

Dr. C. E. Kircher has been made manager of research, Detrex Corp.

Harold Ruehl has been named assistant chief engineer, Erickson Tool Co.

Arthur L. Clements, Jr. has joined the sales engineering staff of The Glastic Corp.

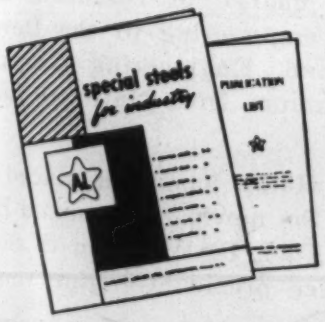
Edward C. Jupa has been elevated to senior design engineer, Armour Research Foundation of Illinois Institute of Technology.

Claude H. Leland has been made assistant chief engineer, Industrial Heating Equipment Co.

Fred H. Johnson has been appointed engineering consultant to the vice president in charge of planning and administration, Inland Steel Co. Other new appointments by the company include **S. W. Benson II** as assistant chief engineer in charge of flat products and shape products engineering, **T. W. Myhre** as assistant chief engineer in charge of primary products, operating services and services engineering, **C. B. Pound** as shape products engineer, and **R. A. Hogue** as flat products engineer.

(More News on p. 198)

FIRST COST can be the LEAST COST if it's the LAST COST



WRITE TODAY

For These Publications

1. SPECIAL STEELS FOR INDUSTRY . . . 16 pages of essential data on the proper selection and application of principal AL special alloy products: stainless, tool and electrical steels and sintered carbides.

2. PUBLICATION LIST . . a complete listing of all AL publications, both technical and non-technical (over 100 in all), with a handy order form for your convenience.

ADDRESS DEPT. MM-68

First cost is never the whole story. Length of service and cost of upkeep are equally powerful factors in determining the lifetime cost . . . the *real* cost of an object.

Nor does it have to be something glamorous. Even such everyday things as kitchen garbage containers and work surfaces, mixing bowls and flour sifters, etc., are transformed when they're made of Allegheny Metal. They look better, clean easier, last many times longer. That's because *no other metal* is at once as hard and strong, as resistant to wear and corrosion, as stainless steel. Even where the use of Allegheny Metal results in higher first cost (and quite often it doesn't!) it is sure to cost far less in the long run.

Does that give *you* ideas about adding new sales appeal to your product? Or reducing maintenance, repair and depreciation costs in your equipment? If so, our engineers are ready to help you work them out. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

Make it BETTER-and LONGER LASTING-with

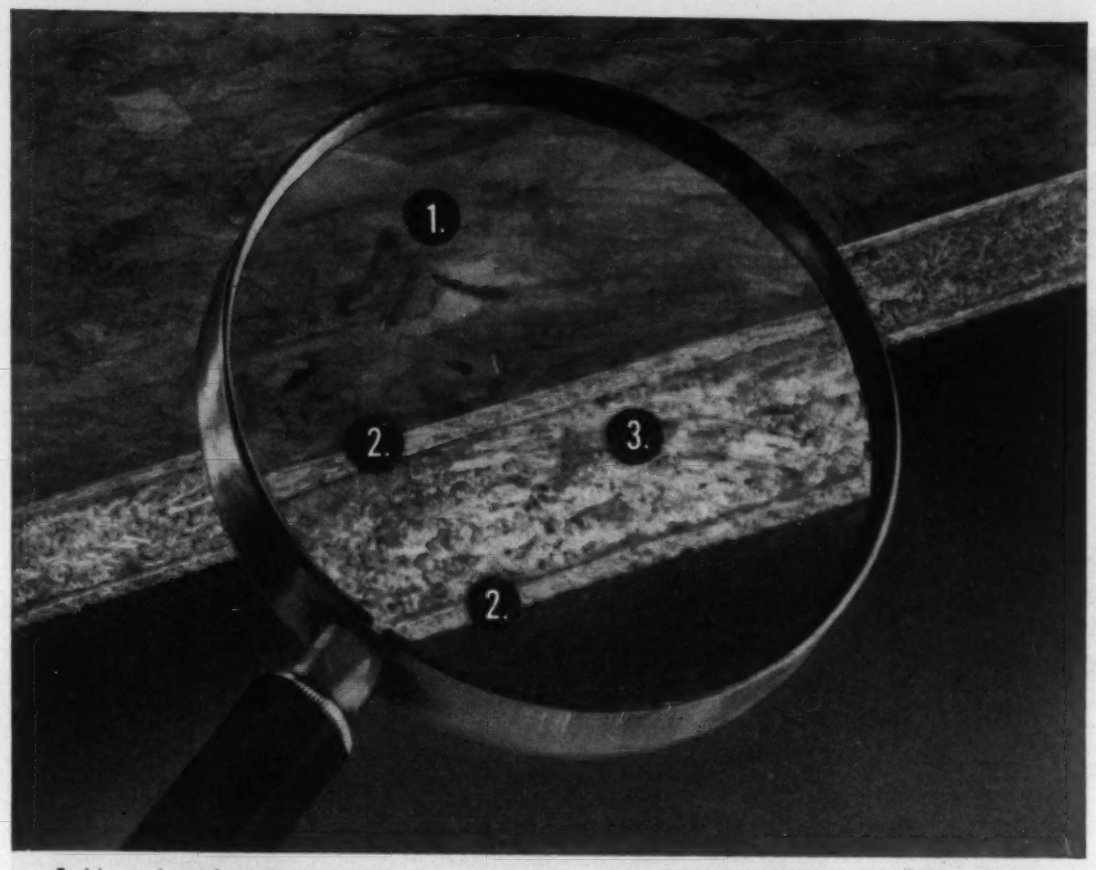
Allegheny Metal

W&D 5399C

AL TIME-TESTED STAINLESS STEEL

Warehouse stocks carried by all Ryerson steel plants

For more information, turn to Reader Service Card, Circle No. 384



1. Novoply surface is remarkably flat, and its mosaic-textured look makes it a handsome panel for decorative use. **2.** Top and bottom surface plies are precision-made wood flakes. **3.** Center ply is of specially graded wood chips. Both flakes and chips are resin-coated and -impregnated.

SEE HOW THIS

3-ply wood-plastic laminate fits in with *your* design ideas!

United States Plywood's NOVOPLY is rigid, super-flat, easy to work, mechanically strong, has tremendous design potential

SEND FOR FREE SAMPLE AND ENGINEERING DATA BOOKLET—Test it yourself!

What is Novoply? Novoply is a 3-ply panel composed of faces of specially prepared wood flakes and a core of wood chips, all resin-impregnated, and molded under heat and pressure to make a very dense, hard, flat panel.

Novoply advantages. It's tremendously strong, stiff, highly water-resistant, with unusual dimensional stability in all directions. Novoply is very stable, expanding and contracting less than 0.3% even under conditions of extreme humidity. It's good *both* sides, glues readily, fabricates easily, is well adapted to modern, high-speed woodworking equipment. Its moisture resistance and 3-ply construction make it extremely flat and warp-resistant.

Novoply is being used as a core stock for high-pressure laminates such as Micarta®, as a core for veneered furniture, as practically warp-free sliding doors for closets, as wall paneling and counter fronts, and for decorative uses and sliding doors in furniture.

NOVOPLY PANEL SPECIFICATIONS: Thickness: ¾"; **Sizes:** 24" x 72", 24" x 96", 30" x 48", 30" x 60", 30" x 72", 36" x 72", 48" x 48", 48" x 72", 48" x 84", 48" x 96"; also cut-to-size for volume users from panels 6' x 12' and 4' x 16'. Available in ⅜", ⅝", 11/16", 1" thicknesses, sizes 48" x 96", and other sizes. **Important Note:** Only slight extra cost for long-length Novoply panels up to 16'.

NOVOPLY®
by **Weldwood®**
A product of
United States Plywood Corporation
World's Largest Plywood Organization
87 Distributing Units in Principal Cities

United States Plywood Corporation MM-8-5
Weldwood Building
55 West 44th St., New York 36, N. Y.

RUSH my free sample of Novoply, and engineering data booklet detailing results of Novoply tests conducted by a famous independent research and testing laboratory.

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... **STATE** .....

For more information, turn to Reader Service Card, Circle No. 454

news of ENGINEERS

Allen Leroy Emptage has been made head of Interchemical Corp.'s central Engineering Department.

C. Roger Sutton has joined the Development and Research Div., The International Nickel Co., Inc., as a member of the Stainless Steel and Heat Resistant Alloys Section. In the same division of the company, **M. D. Bellware** has become a member of the Welding Group of the Technical Service Section, and **Leon M. Petryck** has been made a research metallurgist in the Welding Section of the Research Laboratory.

Donald E. Wingate has been given the duties of chief engineer, Ipsen Industries, Inc.

Edward P. Gebhard has been named technical director, Defense Products Div., The M. W. Kellogg Co.

O. A. Olson has been promoted to assistant director of research, Laclede-Christy Co., Div. of H. K. Porter Co., Inc.

James L. Oberg has joined Metal & Thermit Corp. in the capacity of technical advisor.

Arthur B. Warner has been advanced to chief engineer, Minnesota Rubber and Gasket Co.

Donald Storey has been named vice president in charge of manufacturing and **Paul E. Sanford,** vice president in charge of engineering, Molded Fiberglass Co.

Emory W. Worthington has been appointed vice president-engineering, George F. Motter's Sons.

R. P. Lee has been made senior engineer in charge of corrosion and materials engineering in the Development and Engineering Department, Titanium Div., National Lead Co.

James C. Hoiby has been placed in charge of the newly reorganized Engineering Div., D. W. Onan & Sons Inc., as vice president-engineering.

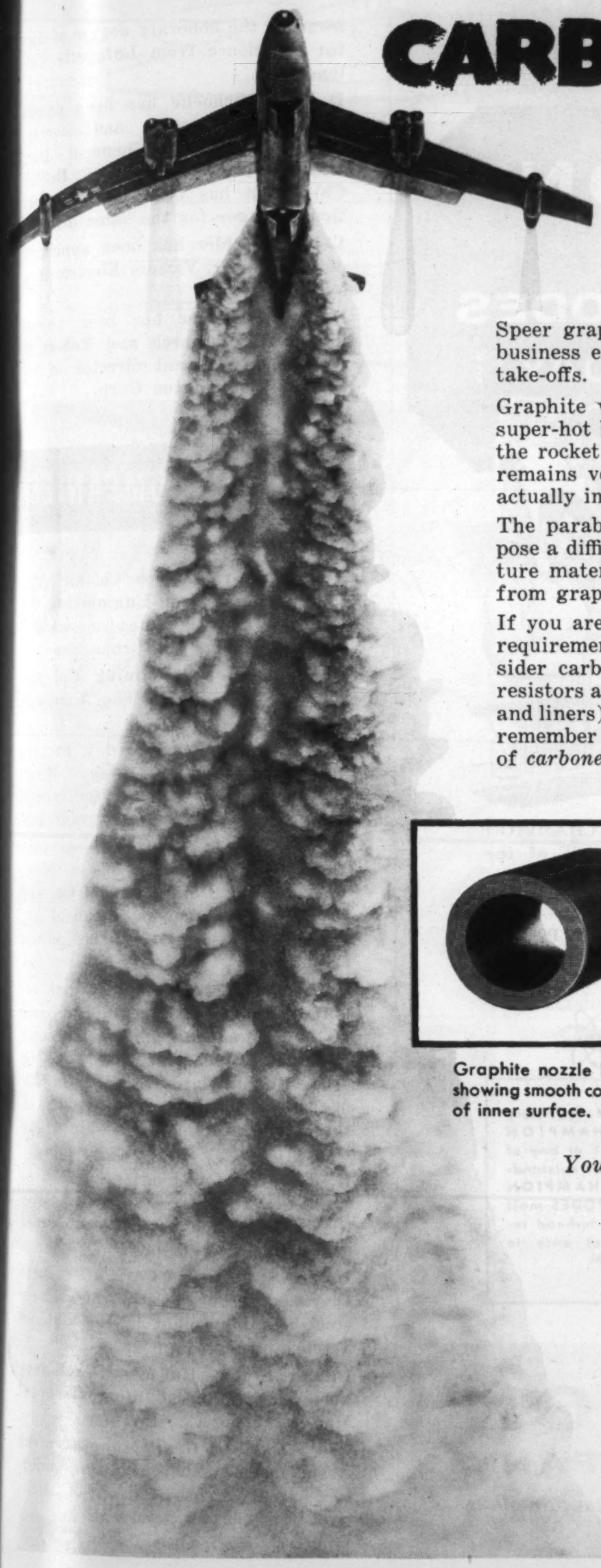
Clyde B. Faverty has been named director of manufacturing, Pullman-Standard Car Mfg. Co.

A. B. Kennison has been elected a vice president of Servel, Inc., and will serve as the company's coordinator of research and product development.

H. I. Wolff has been given the newly-created post of assistant manager, Manufacturing - Development Department, Shell Chemical Corp.

Benjamin F. Shepherd, chief metallurgist, Ingersoll-Rand Co., has been

THRUST for jet-assisted take-offs . . .



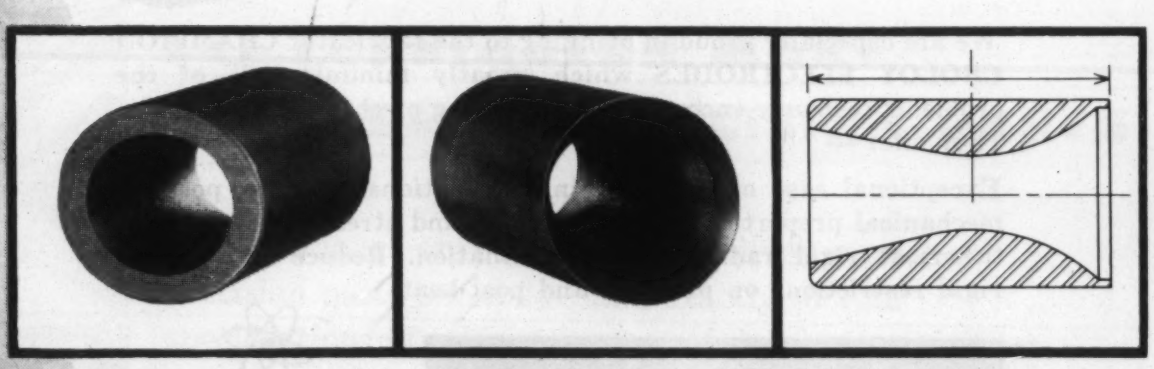
CARBONEERING *by Speer*

Speer graphite (Grade 3474) forms this nozzle insert, the business end of a JATO rocket tube for assisting aircraft take-offs.

Graphite was used because it can take the full thrust of super-hot blast gases without warping the critical shape of the rocket orifice. And, its thermal coefficient of expansion remains very low at high temperatures while its strength actually increases up to 5432° F.

The parabolic contour of the nozzle's inner surface would pose a difficult fabricating problem with most high-temperature materials. But this complex shape is easily machined from graphite within tolerances of + .005".

If you are searching for a material to meet special design requirements look to Speer and Carbon. For example: consider carbon for its electrical characteristics (in brushes, resistors and contacts), its chemical inertness (in containers and liners), its quality of self-lubrication (in bearings). And remember to call on Speer for the latest advances in the field of *carboneering*.



Graphite nozzle insert showing smooth contour of inner surface.

Orifice of insert is shaped to deliver maximum thrust.

Cut-away view shows unusual machining requirements.

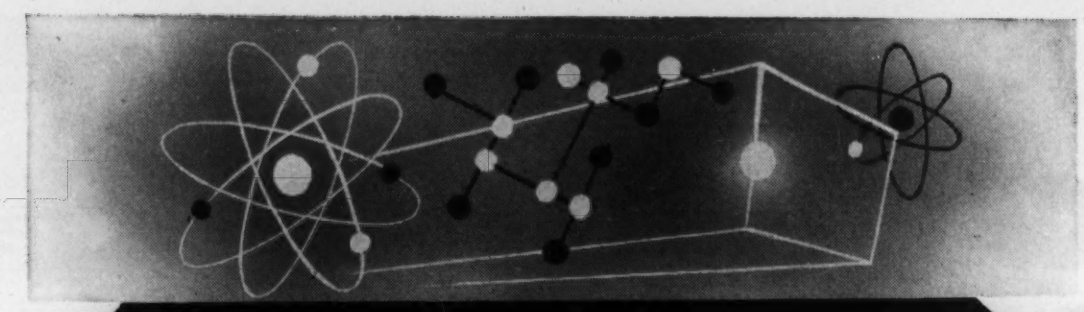
You be the judge of carbon's versatility

Carbon can be:	Carbon has:
Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	
Planed	**Carbon is:**
Hobbed	Not wetted by molten metals
Ground	Non-warping
Molded	Chemically inert
Extruded	Self-lubricating

SPEER *Carbon Co.*

St. Marys, Pennsylvania

For more information, turn to Reader Service Card, Circle No. 466

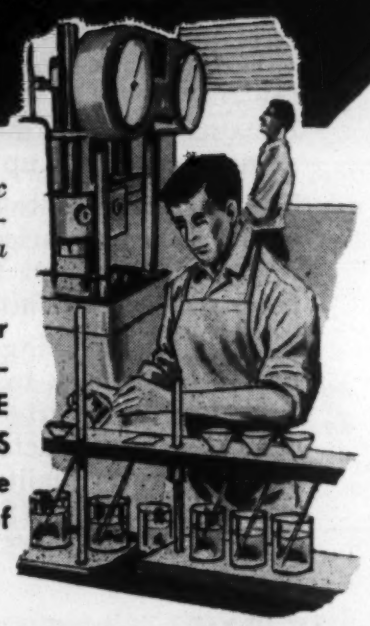


CHAMPION

brings you the

WELDING ELECTRODES

of the Future . . . TODAY!!



Whatever your requirements in an arc welding electrode, CHAMPION'S Research and Engineering have designed a product that is tops in its class.

All CHAMPION ELECTRODES, whether MILD STEEL • IRON POWDER CONTACT • LOW ALLOY - HIGH TENSILE • LOW HYDROGEN • STAINLESS STEEL or HARD SURFACING have built in quality and excellence of performance.

We are especially proud in bringing to the fabricator **CHAMPION CROLOY ELECTRODES** which greatly minimize all of the problems formerly encountered in welding of chrome-moly steels. They offer —

Exceptional ease of handling in all positions. Highest possible mechanical properties; both as welded and stress relieved. Pass the most rigid radiographic examination. Reduce the former rigid restrictions on pre-heat and post-heat.

Header tee connections

For the full story on CHAMPION CROLOY or any of the other outstanding CHAMPION ELECTRODES mail your letterhead request at once to Dept. M

THE CHAMPION RIVET COMPANY

CLEVELAND 5, OHIO EAST CHICAGO, INDIANA

For more information, turn to Reader Service Card, Circle No. 463

news of | ENGINEERS

awarded the honorary degree of doctor of science from Lafayette College.

D. Lorin Schoene has been named director of research and development, Naugatuck Chemical Div., United States Rubber Co. **F. Dudley Chittenden** has been made production manager for the same division.

L. W. Buechler has been appointed chief engineer, Vickers Electric Div., Vickers Inc.

Hellmuth Walter has been named director of research and **Robert S. Sherwood,** assistant director of research, Worthington Corp.

news of | COMPANIES

American Brake Shoe Co. has purchased **The Denison Engineering Co.** Denison now becomes a wholly-owned subsidiary of Brake Shoe.

Anaconda Copper Mining Co. has changed its name to The Anaconda Co.

Cory Corp. has acquired a factory building at 2010 S. Marshall Blvd., Chicago. The new plant facility will be occupied principally by the company's Service Department.

Versenes Inc., purchased in Nov., 1954, by **The Dow Chemical Co.** and operated since then as a subsidiary, has been absorbed by the parent company.

Michigan Steel Casting Co. has acquired **Standard Alloy Co.** The name of the merged companies has become Michigan-Standard Alloy Casting Co., with Standard Alloy moving its operations, patterns and certain of the production personnel into the larger plant at Detroit.

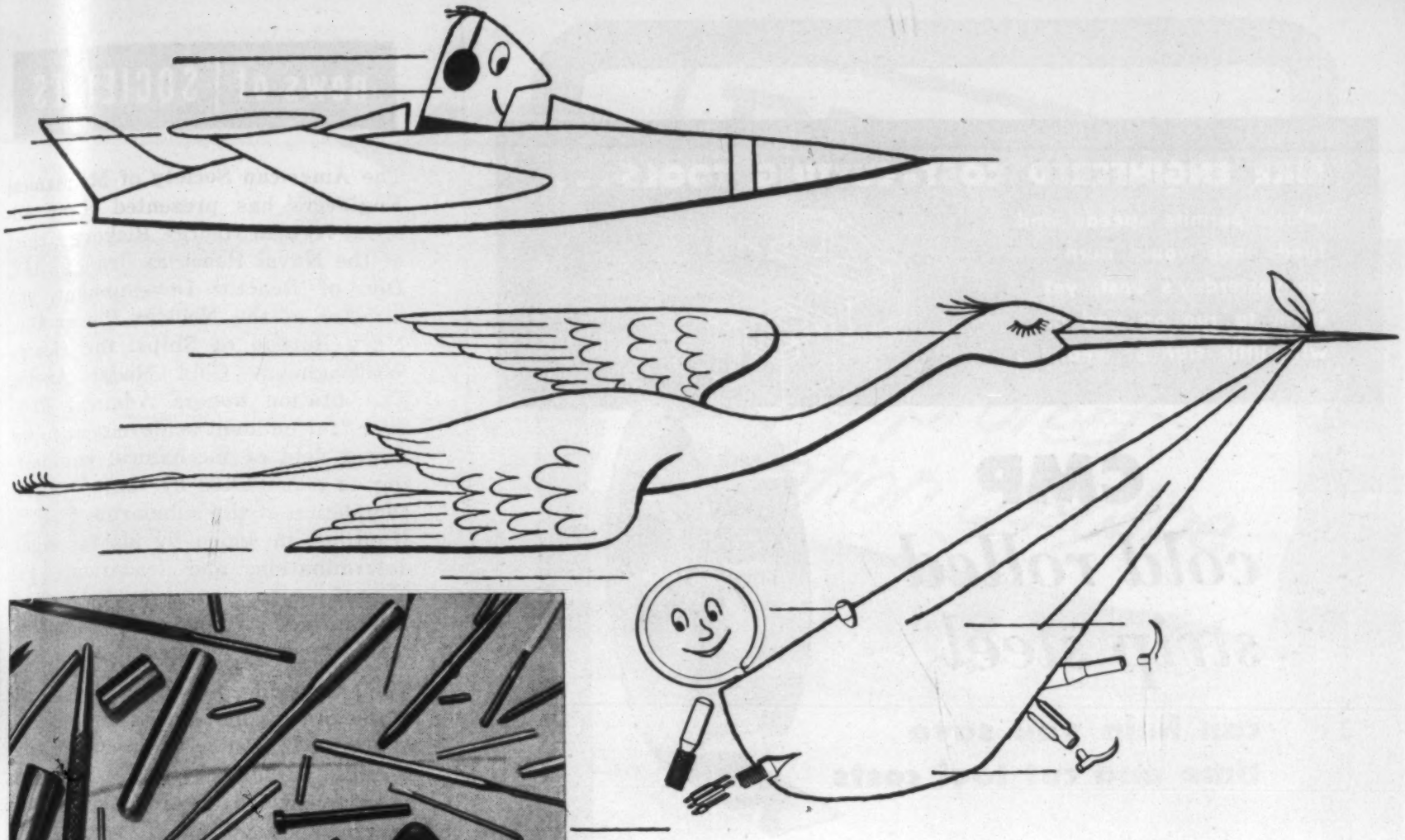
H. K. Porter Co., Inc., has purchased **Vulcan Crucible Steel Co.,** and the latter company will be operated as a division of Porter.

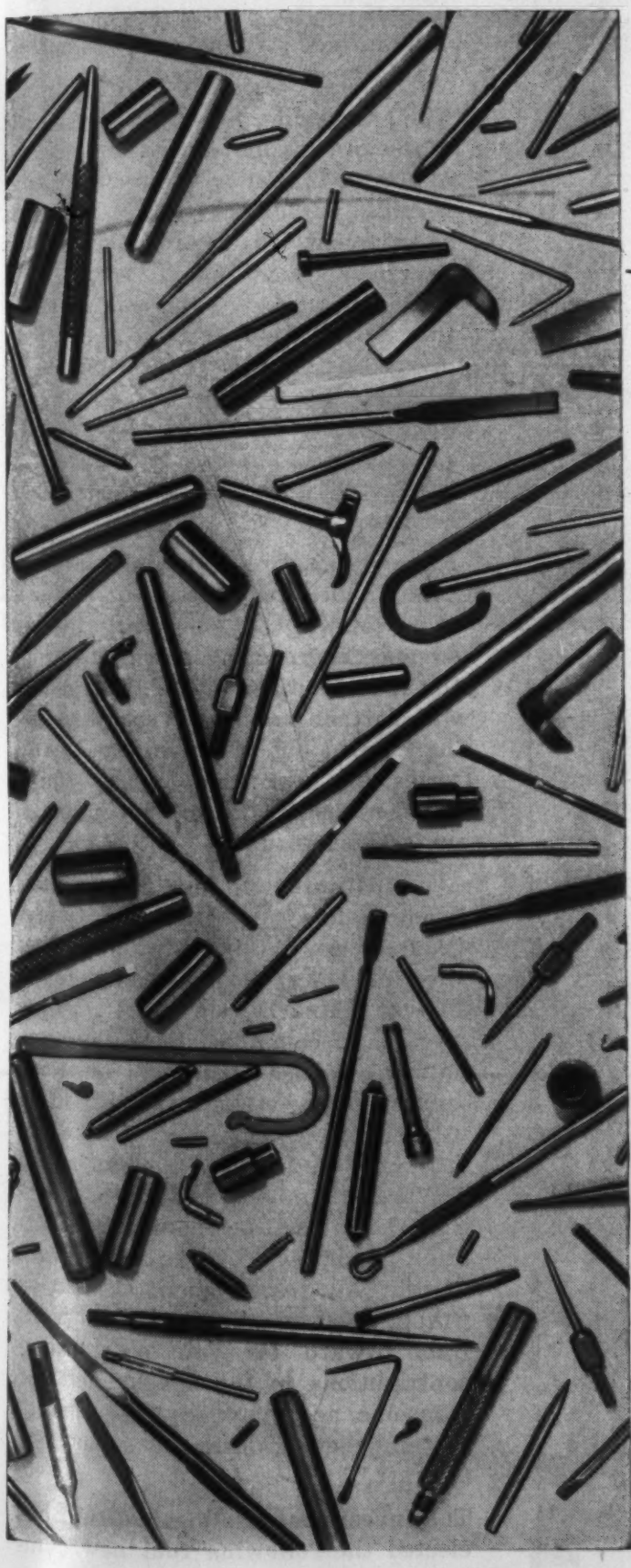
United States Steel Corp.'s Products Div. has begun operation of its new steel container plant in Pennsauken Township, near Camden, N. J.

United States Hoffman Machinery Corp. has purchased **Intercontinental Manufacturing Co., Inc.**

The **American Gear Manufacturers Assn.** has elected Marvin R. Anderson, executive vice president of Michigan Tool Co., as president.

(News of Societies on p. 202)





When speed is important—

LET TORRINGTON MAKE YOUR SMALL PRECISION PARTS

You can count on Torrington to deliver your small precision parts *promptly*—and exactly to your specifications of tolerances, temper, hardness and finish.

Whether you order a hundred or a million pieces—we can produce them *faster, better and for less* than you can make them yourself. Send a sample part or your blueprint for our quotation. And ask for our Condensed Catalog which shows many of the parts we can make at significant savings.

THE TORRINGTON COMPANY
Specialties Division
777 Field Street, Torrington, Conn.

TORRINGTON *SPECIAL* **METAL PARTS**

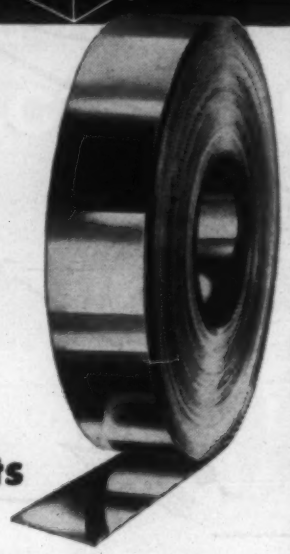
Makers of Torrington Needle Bearings

For more information, turn to Reader Service Card, Circle No. 432

LIKE ENGINEERED COST-CUTTING TOOLS . . .

which permits speeds and feeds that would burn up yesterday's best, yet seem to run on and on with little sign of wear . . .

CMP
cold rolled strip steel
can help you save time and cut tool costs



Frequently, CMP can do as much and more to help you save time and cut tool costs as modern tools themselves.

By processing cold rolled strip steel to restricted specifications, it often is possible to develop working qualities that will permit forming operations to be speeded up as much as 25% without increased tool wear.

Again, qualities may be imparted to the steel which will permit simplification of tooling, and even elimination of operations.

And, always, because of the customary dimensional precision of CMP Cold Rolled Strip Steel, there is more footage per coil . . . fewer coil replacements are required on automatic-feed operations . . . there is less tool wear . . . fewer stops for tool changes and assembly is speeded.

You are invited to use CMP's experience along this line with a view to developing restricted specifications to cut your end-product cost.

CMP WHERE YOU CAN GET SPECIFIC SPECIFICATIONS FOR SPECIFIC JOBS
Low Carbon • High Carbon, Annealed or Tempered • Stainless • Alloy • Electro Zinc Coated

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news of | SOCIETIES

The American Society of Mechanical Engineers has presented Rear Admiral Hyman George Rickover, chief of the Naval Reactors Branch, AEC Div. of Reactor Development, and director of the Nuclear Power Div., Navy Bureau of Ships, the George Westinghouse Gold Medal Award. The citation honors Admiral Rickover "for eminent achievement in the power field of mechanical engineering as exemplified by the successful completion of the submarine U. S. S. Nautilus, in which by his foresight, determination, and leadership, the idea of nuclear power generation was transformed from speculation to reality."

The American Society for Testing Materials has announced the election of Claire H. Fellows, director, Engineering Laboratory and Research Department, The Detroit Edison Co., as president, and R. T. Kropf, vice president and director of research, Industrial Thread Div., Belding Heminway Co., Inc., as vice president. In addition, the society has authorized the organization of a new committee, designated F-1 on Materials for Electron Tubes and Semiconductor Devices.

Engineering Foundation at its recent annual meeting approved applications totaling $61,850 for grants to advance engineering research during the 1955-1956 fiscal year. The grants will further twenty-six projects being carried out in university laboratories all over the country under sponsorship of the major engineering societies.

The **Institute of the Aeronautical Sciences** has presented The Octave Chanute Award for 1955 to Major General Albert Boyd, commander of Wright Air Development Center, "for major contributions to the aeronautical sciences through improvements in the techniques of flight testing, the development of facilities for flight testing, and the evaluation of large numbers of military aircraft." The Institute named Dr. Gottfried Guderley, who also is with Wright Air Development Center, as winner of this year's Thurman H. Bane Award for "his outstanding contributions to the development of transonic aerodynamics essential to the engineering design of supersonic aircraft."

The **Investment Casting Institute** has elected the following four new com-

Arc welding of the Filter/Separator.

Gasoline Filter/Separator made by Bendix-Skinner Division almost entirely of Revere 90-10 Cupro-Nickel.

It has been found that minute traces of water in aviation gasoline can stop the engine when flying in low temperatures, as at high altitudes, or over the pole. The amount of water involved is so small that it would not bother an automobile carburetor. To remove it for safe flying requires a special Filter/Separator. All metal parts going into this filter were specified to be 90-10 Cupro-Nickel. One of the contractors for the U. S. Navy is the Bendix-Skinner Division of the Bendix Aviation Corporation, Royal Oak, Mich. When Bendix-Skinner obtained the order, it called in Revere's Technical Advisory Service. A complete study was made of the blueprints and specifications, in order to set up the most economical purchasing schedules. When production began, personnel from the Welding Section of the Research and Development Laboratory maintained by Revere in Rome, N. Y., went to the Bendix-Skinner plant to share their know-how with the welders, so as to be sure the welds would pass strict inspection, yet be made at competitive costs.

Cupro-Nickel, 90-10, is highly resistant to corrosion and other forms of attack. Because it contains only 10% nickel, it is more economical than the richer alloys, yet in many applications just as satisfactory. We suggest you look into it.

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panies to membership: Brace, Inc., Minneapolis; Illinois Precise Casting Co., Chicago; Industrial Fine Castings Ltd., Toronto; and A. P. Green Fire Brick Co., Mexico, Mo.

The **Manufacturing Chemists' Assn.** has elected J. R. Hoover, president, B. F. Goodrich Chemical Co., to chairmanship of the board of directors. Mr. Hoover succeeds Fred J. Emmerich, president, Allied Chemical & Dye Corp., who continues as a director of the association.

The **Porcelain Enamel Institute** has promoted William N. Brinker to the position of market development manager and has named Elizabeth O'Connor as assistant secretary of its National Safe Transit Committee. In addition, PEI has announced the formation of the Aluminum Div. within its organizational structure. Charles P. Lohman of Pemco Corp. is chairman of the newly-formed division.

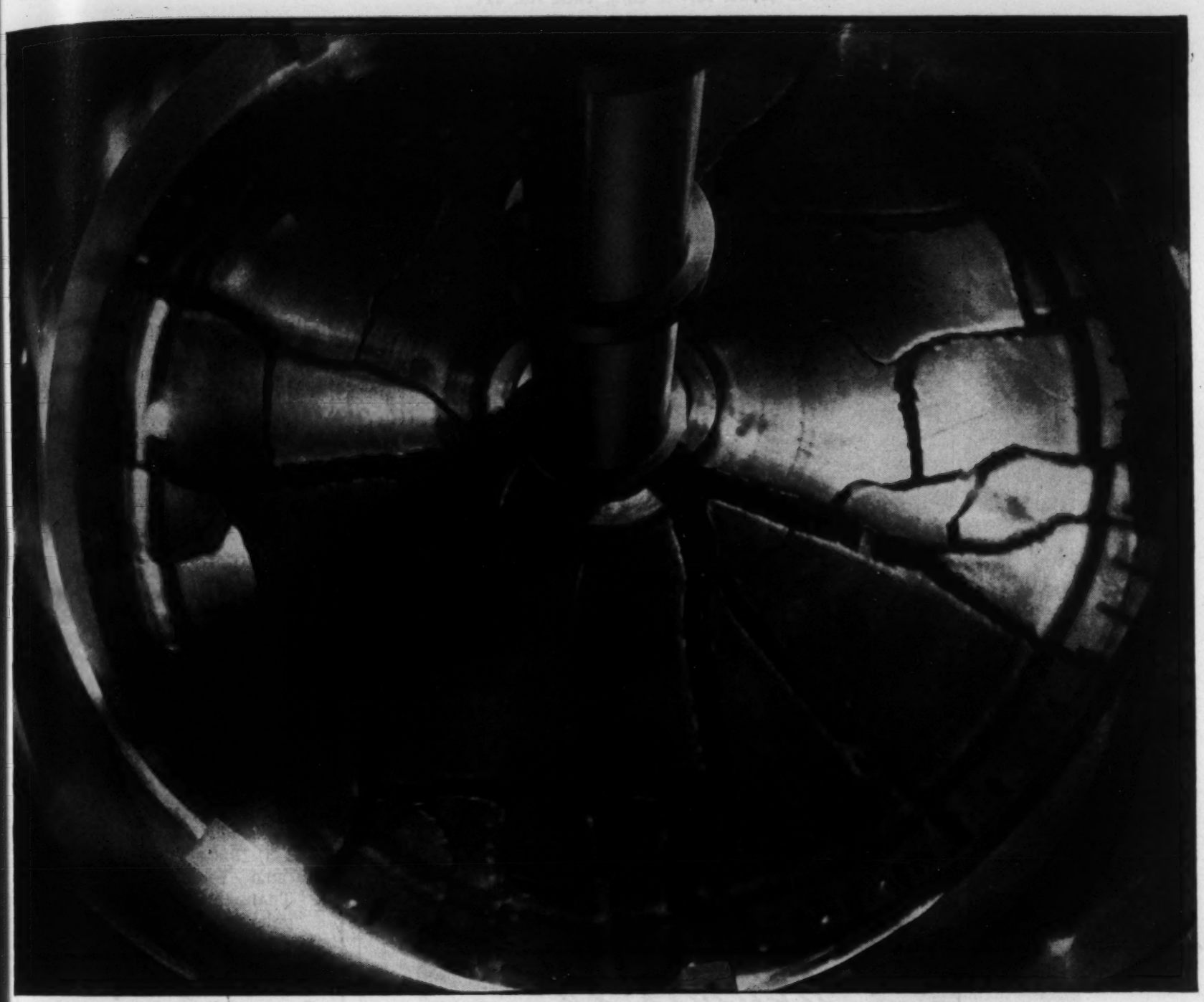
The **Society of Women Engineers** has elected Mrs. Lois G. McDowell, assistant professor of mechanical engineering, Illinois Institute of Technology, as national president for 1955-56.

The **National Screw Machine Products Assn.** has added to its membership the following seven new companies: Abbott Products, Inc., Whitestone, N. Y.; Columbus Jack Corp., Columbus, Ohio; Economy Machine Products Co., Chicago; Mantel Screw Products Co., Milwaukee; Naugatuck Automatics, Inc., Naugatuck, Conn.; Nutmeg Screw Machine Products Co., Wolcott, Conn.; and Owen Manufacturing, Inc., Litchfield, Ill.

The **Standards Engineers Society** recently announced that one of the highlights of its fourth annual meeting in Hartford, Conn., Sept. 29 to Oct. 1, will be the presentation of awards to outstanding engineers who have contributed to the development and use of standards.

The **Society of the Plastics Industry**, during its annual meeting held aboard the Queen of Bermuda, elected Norman Anderson, president, General Molded Products, Inc., as president to succeed John J. O'Connell, who is now the new chairman of the SPI board of directors. Alan S. Cole, executive vice president, Breskin Publications, Inc., is the newly-elected vice president.

(Meetings & Expositions on p. 206)



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Engineers asked: "How strong and tough is titanium?" Here is one dramatic test which answered part of the question. The 18-pound Rem-Cru C-130AM titanium alloy jet compressor wheel shown, withstood more rpm's than the strongest steel. Engineers wanting to see how much it would take, finally had to notch it before it would break.

In other experiments, research engineers took titanium which had been in triple jeopardy from temperature, stress and salt water corrosion, and then tested to see how much more punishment it could take. Tests proved conclusively that there was no time limit on toughness for all grades of Rem-Cru titanium. For example, Rem-Cru A-70, stressed for five years (43,500 hours) at 80,000 psi, showed no loss in ductility. Rem-Cru C-110M and C-130AM high strength alloys also retained toughness under many severe combinations of temperature and stress. Both remained ductile after 1000 hours at high stress and temperatures up to 600F.

So if you're looking for a *strong, tough* metal, with light weight and exceptional corrosion resistance, REM-CRU titanium is the answer. And you are sure of an adequate supply of REM-CRU titanium, in most sizes and grades, due to REM-CRU's expanded facilities.

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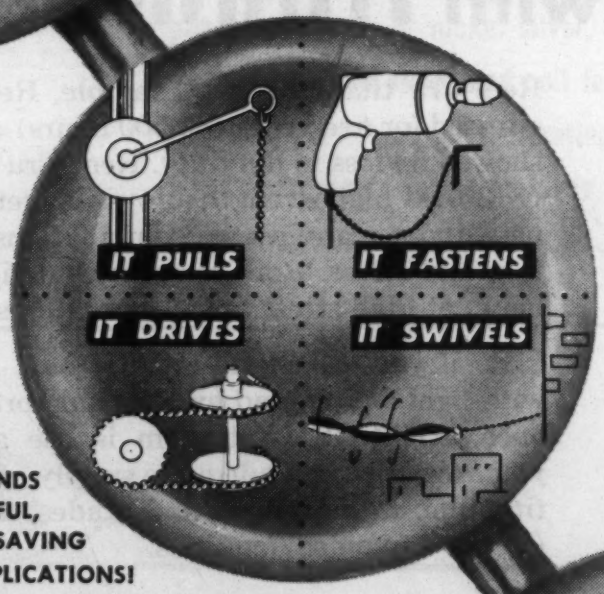

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Meetings & Expositions

METALWORKING MACHINERY & EQUIPMENT EXPOSITION. Chicago. Sept. 6-17, 1955.

PRODUCTION ENGINEERING SHOW. Chicago. Sept. 6-17, 1955.

NATIONAL MACHINE TOOL BUILDERS ASSN., machine tool show. Chicago. Sept. 6-17, 1955.

METAL POWDER ASSN., fall meeting. Hot Springs, Va. Sept. 9-11, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting and production forum. Milwaukee. Sept. 12-15, 1955.

PORCELAIN ENAMEL INSTITUTE, Annual Shop Practice Forum. Columbus, Ohio. Sept. 14-16, 1955.

ASSN. OF IRON AND STEEL ENGINEERS, annual convention. Chicago. Sept. 26-29, 1955.

ATOMIC INDUSTRIAL FORUM trade fair. Washington, D.C. Sept. 26-30, 1955.

STANDARDS ENGINEERS SOCIETY, fourth annual meeting. Hartford, Conn. Sept. 29-Oct. 1, 1955.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct. 1-5, 1955.

WORLD PLASTICS FAIR AND TRADE EXPOSITION. Los Angeles. Oct. 5-9, 1955.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Oct. 6-7, 1955.

PRESSED METAL INSTITUTE, annual convention. Ashville, N. C. Oct. 9-13, 1955.

ELECTROCHEMICAL SOCIETY, fall meeting. Pittsburgh. Oct. 9-13, 1955.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct. 11-15, 1955.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div, fall meeting. Philadelphia. Oct. 17-19, 1955.

AMERICAN SOCIETY FOR METALS, National Metal Congress and Exposition. Philadelphia. Oct. 17-21, 1955.

AMERICAN WELDING SOCIETY, national fall technical meeting. Philadelphia. Oct. 17-21, 1955.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Milwaukee. Oct. 19-21, 1955.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Oct. 24-25, 1955.

CORNING GLASS BULLETIN

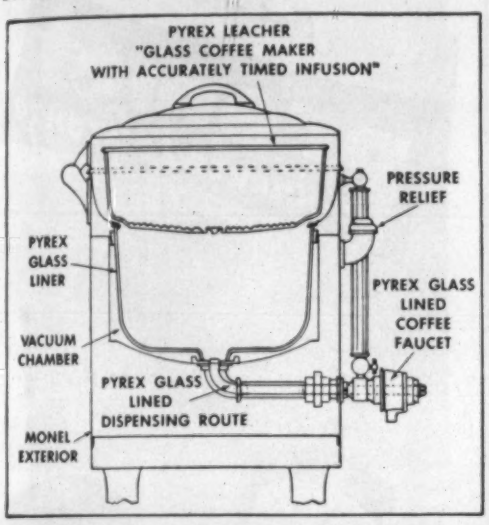
FOR PRODUCT DESIGNERS

"Urning" power

Coffee time these days is almost anytime.

And behind many a steaming cup there lies *glass*—a PYREX brand glass.

Take those big urns that gleam and glisten at your favorite snack shop. Outside, shining monel metal. But, on the inside, where the piping hot coffee is in the making, you'll find glass. As in this cross section of a coffee maker.



Glass liners of this type are made from that unusually versatile glass called PYREX brand No. 7740. And, for good reason.

This is a *balanced* glass. It has remarkable ability to take continuous heat, and still not crack when temperatures drop. It's mechanically strong, too, stands up under lots of physical abuse.

The clincher—glass neither *adds* to nor *detracts* from the taste. This glass will *not* contaminate by taking from or adding to what you make in it (or pipe through it) —coffee, milk, tomato juice, or something with even more zing, like fermented juice from plump grapes.

And any PYREX brand glass that handles foods and such is quickly and effectively cleaned with a minimum of effort.

Which suggests that the "urning" power of glass in some form might well be working for you.

As a start, take a look at "Properties of Selected Commercial Glasses"—Bulletin B-83; and/or Bulletin IZ-1, "Glass—its increasing importance in product design." Free.

Getting the mostest with the leastest

Taking to heart, with minor modifications, the advice about getting there "fustest with the mostest," we present Pattern No. 70 Low-Brightness Lens Panels.

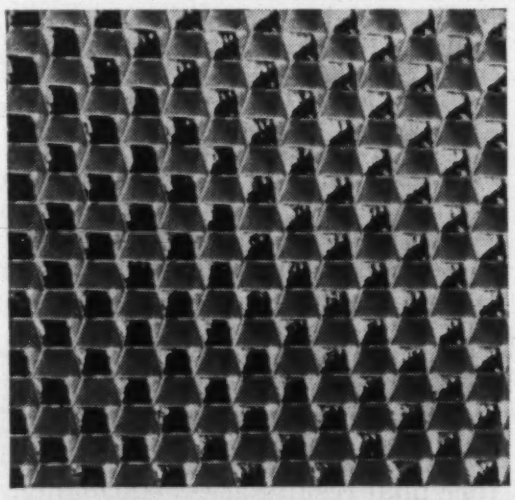
Said panels get there "mostest with the leastest"—*most* useful light, *least* glare.

Key to this light that's bright but not glaring is "a uniform configuration of six-sided glass pyramids"—otherwise known as prisms.

Prisms in light control are not new. But mass-produced, large panels, with prisms *built-in* represent quite an achievement in technology.

This we call to your attention not because you may have a problem of adequate lighting. We cite it, rather, as another indication of what lies behind the motto: "Corning means research in Glass."

Research activities have led us up a number of unusual glass paths. Case in point—glass that laughs at heat, that stands up to high temperatures (1200°C.) and chemical attack in the manner usually expected only of fused silica.



Other cases in point—glass that's optically perfect but capable of withstanding wind moving in closed wind tunnels at twice the speed of sound; glass that directs infrared and ultraviolet rays at will; glass that handles metal-eating acids with ease.

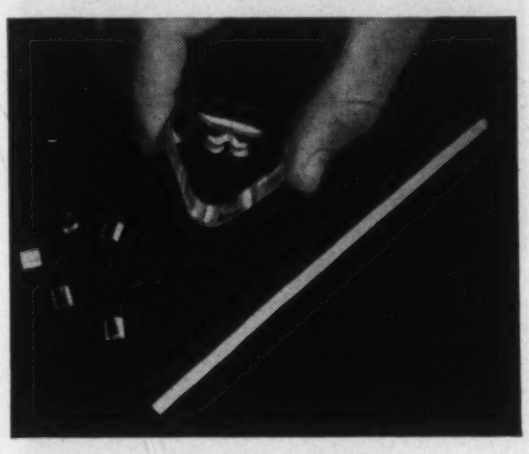
Among our 50,000-odd formulas for glass, there may be *one* with just the right balance of optical, thermal, chemical, mechanical and electrical properties, to solve one of your materials problems.

"Glass and You," a beautiful and informative booklet (if we do say so), will bring you up to date on how hundreds of our friends and customers are getting the "mostest" profits with the "leastest" trouble by making use of special glass researched into being by Corning. Write us for a copy—or check the coupon.

Reflections on some interesting bores

If the decision for precision falls to your lot, these bores may interest you.

These particular bores are the holes in thermometer tubing, a product we turn out by the mile. Practically invisible to the naked eye, these fine holes run to about ¼th the diameter of a human hair.



Yet, they are held to such exceptionally fine inside tolerances as ±.0003".

As you might imagine, mercury pushed into such a small space is hard to see. So, around the bore we build some ingenious white reflectors of white glass. Then, when we form the tubing, we build a lens into it.

Thus, with the help of a white background and magnifying lens, those who must can readily and accurately tell how *hot* hot is and *cold* cold is.

The picture shows a cross section of one type of thermometer tubing. The largest piece in the picture, some 80 times normal size, shows you something of the intricate internal construction of thermometer tubing.

Without modesty we pinpoint this precision in glass to show you what can be done. Tubing, thermometer or just plain tubing, comes in many sizes and types. Write if you'd like to know more about it.

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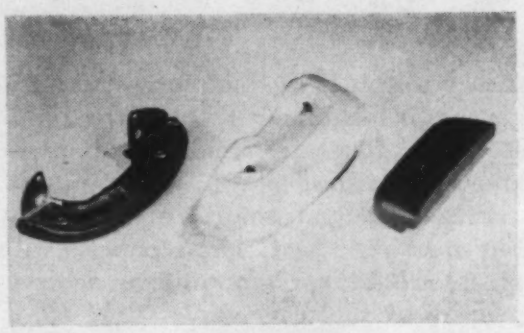
News Digest

continued from p. 14



***One piece molded parts** use vinyl foam, integral skin technique.*
(Brown Rubber Co.)

turers admit that the future of polyurethanes is promising. Costs, too, are an unknown quantity with the polyurethanes. New facilities now building will produce the basic ingredients at lower cost, but at present, cost per pound is high, and the best that can be said is that prices will come down. How far, no one really knows.

Other factors

According to R. G. Welch, Car Design and Maintenance Engineer for New York's transit system, service tests on new seating materials take a minimum of three years, so it will be some time before final results are forthcoming. All three materials are very likely to meet the tests successfully, and future contracts will be let on the basis of cost and design. Welch, who offered a few pointers for prospective suppliers, said, "While the foam for seating must meet our requirements, our approval depends very much on the willingness of suppliers to provide production samples for testing that show imagination and ingenuity. We are interested in low original cost, long life, and low maintenance. For instance, our old spring seats have hundreds of parts—ties, screws, springs, and so on. The new foam seats have only ten or so components, and we have been given a sample of a new integral-skin foamed vinyl seat molded on a steel frame that is essentially a one piece unit. Continued effort of that sort on the part of the rubber companies and seating manufacturers will ulti-

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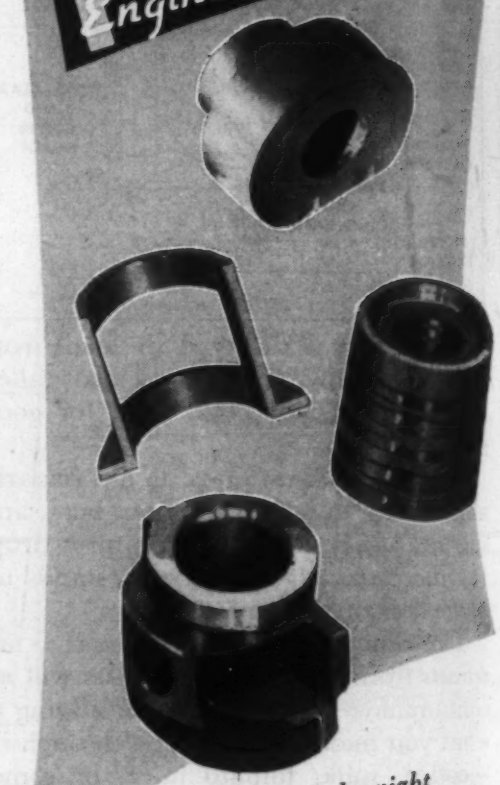

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BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport BRASS CO. — Reporting new developments in copper-base alloys and metalworking methods.

Bridgeport Alloys and Technical Service Help Produce High-Quality Electrical Connectors

Subject to bending during manufacture, Burndy selected Bridgeport Alloy 3089 to prevent fracture at the elbow of this aircraft connector.

In any electrical system, complex or simple, good connectors are as vital as good conductors. Connectors must often meet severe operating conditions and in some installations, must resist corrosion as well as provide strength to the wiring system.

One of the leading manufacturers of connectors is Burndy Engineering Co. of Norwalk, Conn., producers of connectors for electrical systems ranging in size from 12-inch bus bar connectors to connectors for delicate and complex electronic equipment. More than a billion Burndy connectors are now in use.

In making sure connectors are the strongest links in every electrical system they serve, Burndy subjects connectors to rigorous testing.

Burndy connectors undergo tough mechanical and chemical tests before being put into use. In many cases, they must exceed conductors in conductivity in addition to having maximum tensile strength.

To insure top quality, Burndy compression connectors are made from Bridgeport Oxygen-Free Copper Alloy 103. These are crimped at one end to take a conductor cable, and are often flattened and punched for a bolt hole at the other end.

For connectors requiring greater mechanical strength, Burndy specifies Bridgeport Silicon Bronze 609. This high-strength alloy, as tough as mild steel, has exceptional resistance to corrosion and stress cracking. The remarkable cold-working properties of Bridgeport 609 make it an ideal choice for the many severe forming operations encountered during manufacture.

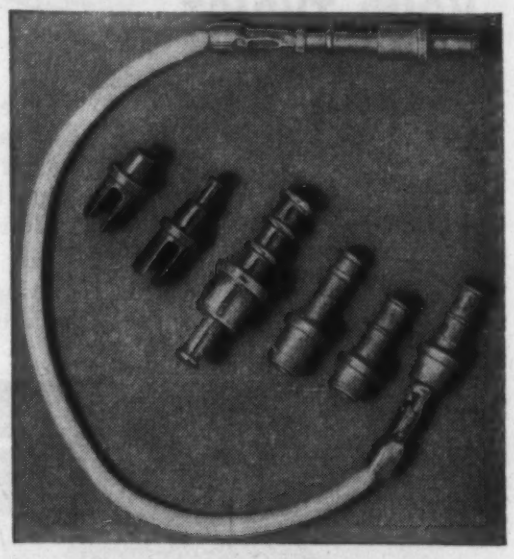
For the small offset connector shown at left, Burndy turned to Bridgeport Alloy 3089 because this alloy can undergo bending without cracking or checking. Alloy 3089 also has good corrosion resistance, and is particularly adaptable to the manufacture of wire and cable connectors as well as hardware fittings.

Product quality isn't just a matter of materials, or of planning, design or specifications. Quality starts with cooperation between the manufacturer of finished products and the suppliers of raw materials.

A typical Burndy "Hylug" connector made from Bridgeport Oxygen-Free Copper Alloy 103.

That's what happened in this case—Burndy and Bridgeport maintain close technical liasion to develop and establish high quality standards for the finished product. When new requirements materialize, new specifications are written—and met. There's a mutual interest in, and responsibility for doing a thorough job.

This close cooperation with manufacturers is only one of the advantages of Bridgeport's Technical Service. This service is available to you without cost. If you are looking for product quality, product improvement and ways of increasing your metal-working profits, call your nearest Bridgeport Sales Office and ask for Technical Service. They'll be glad to lend their assistance to your operations.



Precision Diode Clips & Taper Pins Accurately Machined from Bridgeport Alloy 6

Lerco Division of Lynn-Deatrick, Inc., of Burbank, Calif., is machining—automatically—three clips for crystal diodes and four taper pin terminals, all for use in electronic equipment. One clip is for front-panel mounting. A second is also for front-panel mounting, but contains a blind hole for dip solder. The third clip serves rear-of-panel connections.

The four terminals are a double-end taper, front tapered and back tapered terminals and a front taper terminal with blind hole.

These tiny parts, small but vital to electronic systems, must retain a firm grip on crystal diodes even after multiple insertions. The tapers must be held to close tolerances for consistently accurate fits. The parts themselves must be strong, precise and economical to manufacture.

Lerco uses Bridgeport No. 6 Alloy for these parts with excellent results. The uniform size of Bridgeport No. 6 eliminates fit and tolerance problems. Its consistent high quality assures easy machining to exact dimensions.

Although Lerco's requirements for Bridgeport No. 6 are unique and exacting, No. 6 Rod can satisfy specifications for more than 90% of the jobs requiring free-cutting brass rod.

If you have a product that requires Bridgeport No. 6 Rod, or any other Bridgeport Alloy, consult your local Bridgeport office for information and help. They'll be glad to apply their metal-working knowledge and experience to solving your specific problems.

(3757)

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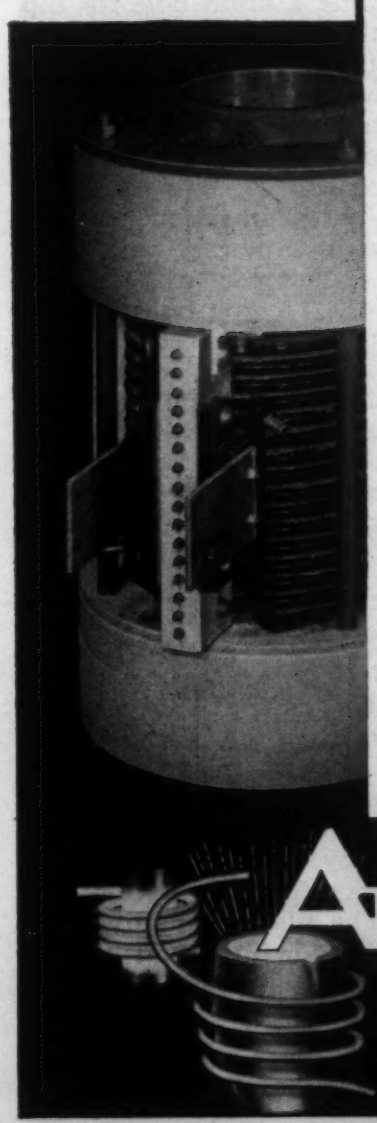
Ajax provides a variety of special furnaces for carbide manufacture and high temperature research. Essentially these are skeleton type furnaces operated by motor generators or high-frequency converters.

Carbide furnaces are usually equipped with Acheson graphite crucibles or sleeves which are good conductors of electricity and capable of attaining high temperatures. For hot pressing of carbides, either graphite or oxide refractory sleeves are employed and the furnaces may be used with either vertical or horizontal presses. For details, write Ajax Electrothermic Corp., Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.



AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

News Digest

mately produce the type of seating we want."

The industrial upholstery and transportation seating market is wide open for new materials, but suppliers must be able to meet high quantity production schedules. The flexible foams, because of their ease of fabrication, chemical and soil resistance, are rapidly taking over aircraft, bus, train, and subway seating, and are just now entering the theatre seat, hospital and hotel furnishings field. One of the most important requirements for foams for such use is fire resistance — which foamed rubber cannot fulfill. Both the Long Island Railroad, which carries more passengers than any railroad, and the New York Subway system now have standards which preclude the use of flammable foams, due largely to a series of fires on Long Island Railroad equipment with foam rubber upholstery. One such fire resulted in an accumulation of explosive gases that totally destroyed the structure of the rail coach.

Tear Test for Titanium

A new test for separating usable titanium sheet from unusable batches utilizes the tearing characteristics of a sample of the material. Developed at Douglas Aircraft's Materials Laboratory, the test shows sheet quality in terms of brittleness, formability and strength factors, and represents more than the simple tear strength of the sheet.

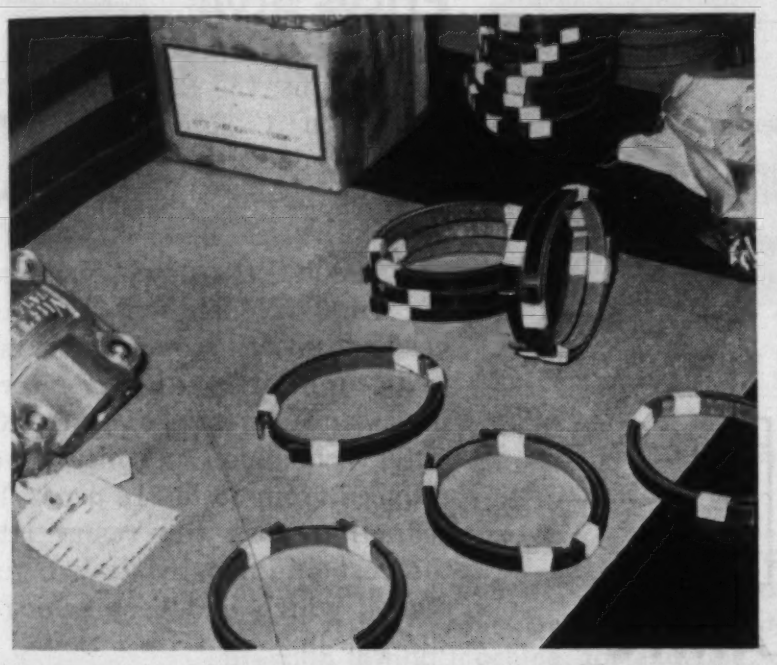
The test sample is a small specimen cut from sheet with a keyhole type notch. The "ears" of the specimen are pulled apart so that the tear originates at the bottom of the keyhole. The testing machine, a Baldwin-Lima-Hamilton 5000-lb universal tester, applies an increasing load in a normal setting for tension testing of metals. The load is recorded along with strain during the test. Typical test results show a steadily increasing load up to a maximum value re-

For more information, turn to Reader Service Card, Circle No. 372

Polyken TAPES

CONTROLLED STRENGTH

KEEP RINGS IN SHAPE, PADDING IN PLACE



These compact coils in the left-hand picture are hydraulic cylinder packing rings. If you took off the strips of *Polyken* Tape that hold them, they'd tend to straighten out. That would make them hard to handle and they'd take a lot more shipping and storage space too.

The other picture shows *Polyken* Tape at work on a different kind of holding job. There a pad of sponge rubber is being put down as a cushioning underlay for carpeting. The sponge rubber is cut to fill in and follow the shape of the room. *Polyken* Tape holds these pieces together, joins them together with a neat and permanent seam, keeps them from slipping out of place once the carpet has been laid.

The tape requirements for these two jobs are not the same. Neither are the conditions under which they are used. To meet the requirements for specific jobs, *Polyken* Tapes have *controlled strength*—the proper combination of adhesive and backing. You use the *controlled strength* required for your job. It's done right and it's done without waste.

The coupon below will bring you complete information.

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INDUSTRIAL TAPES

Polyken Products Department of The Kendall Company

Polyken, Dept. MM-H
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Please send me physical properties and further information on *Polyken* Controlled Strength Tapes.

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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

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ASSOCIATE COMPANIES: Ajax Electrothermic Corporation, Ajax-Northrup High Frequency Induction Furnaces; Ajax Electric Company, Inc. The Ajax-Hultgren Electric Salt Bath Furnace; Ajax Engineering Corporation, Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces

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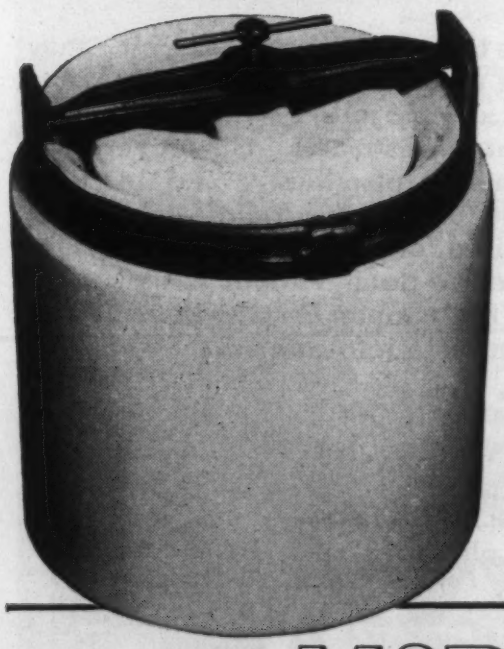

● One-gallon size, designed with recessed, bronze hardware to prevent catching or holding on roller-type mills. Has smooth, long-wearing, high-grade ceramic body inside and out. Straight sides clean easily, quickly. Cover rests on soft rubber gasket, can be tightened by hand without cracking. No leakage. Order from your laboratory supply house now! Ask for PRJ-1G.

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News Digest

quired to start the tear. The shape of the curves from this point on reveals the ductility. A rapid drop off in load with a snapping tearing action shows excess brittleness, while for a ductile, formable piece the tension drops much more slowly as the tear progresses slowly and regularly across the specimen. Thus the test provides data on both strength and fabrication characteristics.

Vinyl Resin Prices Drop

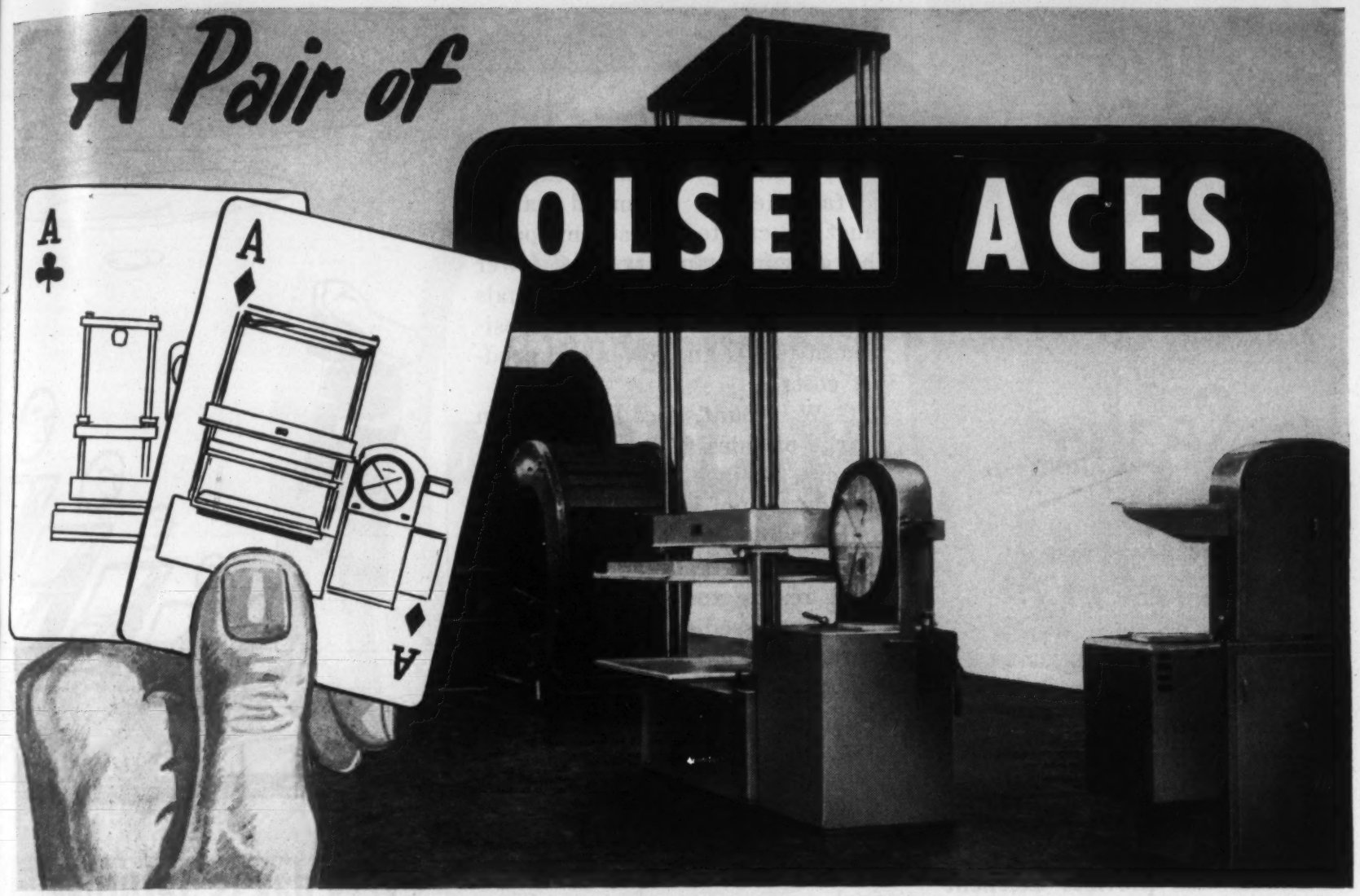
One of the major producers of vinyl resins, the Bakelite Co., Div. of Union Carbide and Carbon Corp., reduced the prices of its entire range of vinyl resins from 9% to 18%.

Non-solvent resins, copolymers of vinyl chloride-vinyl acetate used for sheeting, packaging, rainwear, upholstery and floor coverings, and certain of the 100% vinyl chloride polymers were reduced from 38 to 31¢ per lb. The reduction puts the resins below the cost of imported Italian vinyl resins, which had been selling at 32¢ per lb.

Solvent resins dropped 1 to 3¢ per lb. Such resins are used in coating metal food containers such as beer cans, and for phonograph records, rigid tiles, and industrial coatings.

Vinyl dispersion resins, used in plastisols and organosols (see p. 100) were dropped 6 to 7¢ per lb. Plastisols already enjoying a favorable price relationship in comparison to other corrosion resistant coatings, will benefit further from the price decrease. Plastisols are also used for coating paper and fabrics, slush moldings and structural flexible foams.

Industry use of vinyl resins has grown during the past 20 years from 2½ million lb per year to an estimated 410 million lb in 1954. Until a few years ago resin producers had difficulty meeting demand for vinyls, but last year production exceeded consumption



♦ (center) a 30,000 lb. Olsen ElecΦmatic Compression Testing Machine.

♣ (right) a 60,000 lb. Olsen ElecΦmatic Universal Testing Machine.

From crushing king size crates . . . to pulling fasteners to destruction, this unbeatable pair of Olsen ElectΦmatic Testing Machines answers the need for fast, accurate testing results at a leading container testing laboratory. With the 30,000 lb. compression testing machine, for example, even off center loads are weighed accurately—at all positions on the table supported by the multiple set of levers. Both machines provide the same dependability and ease of operation that you get with every Olsen ElecΦmatic:

- Positive loading speeds . . . infinitely variable from zero to full loading speed.
- Unlimited test stroke . . . a feature of the Olsen electro mechanical loading system.
- 100 to 1 spread of testing ranges.
- Fast, accurate indication of applied load with the exclusive Olsen SelecΦrange Indicating System.
- Instantaneous change of ranges with the flip of a switch *while the specimen is under load.*
- Same zero setting for all testing ranges—no adjustment or compensations when range is changed.

Write today for information about these and the many other features of Olsen ElecΦmatic Testing Machines.

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New Luster-on® Aluminum Sealer

Meets the Requirements of Government Spec. MIL-C-5541

From the makers of Luster-On, the original bright conversion coating for zinc and cadmium comes Luster-On Aluminum Sealer. This new sealer produces a chromate film on aluminum that provides excellent corrosion protection and can serve as a paint base.

Now government approved, Luster-On Aluminum Sealer meets Spec. MIL-C-5541.

Specify Luster-On Aluminum Sealer for:

- Replacing anodizing where hardness is not a prime factor . . . eliminating expensive equipment.
- Salt spray resistance to 600 hours.
- Easy application in one dip at room temperature . . . clear to yellow-brown colors from the same bath.
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Send samples today for free laboratory treatment. See superior results with your own eyes.

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News Digest

by 30 to 35%. With more primary resin producers planning expanded facilities, an expanded market must be created to accommodate the growing capacity. The lower prices for vinyl raw materials will improve the competitive position of vinyls and lower end product costs.

C. W. Blount, Vice President in charge of sales at Bakelite, pointed out, "Since the commercial introduction of vinyl resins to this country by Union Carbide and Carbon, the great majority of all vinyl resins and compounds has been processed and still is, by literally hundreds of relatively small independent businesses—fabricators, molders, extruders, compounders, calenderers and coaters. The reduced prices will [help] the continuing success of these independent businesses." Blount concluded that "Imported vinyl resins have increased in volume some 600% over the past year or so, and ordinarily sell at a price several cents per lb lower than domestically produced polyvinyl chloride. Bakelite's reduced prices will give it a better chance to compete with foreign-made materials."

Ferrocolumbium Prices Drop

A big drop in the price of ferrocolumbium and ferrotantalum-columbium, used for stabilized stainless steels and high temperature alloys, has followed the completion of the Government's stockpiling program. During stockpiling, the Government paid bonuses of 100% on columbium-tantalum ores to stimulate production. The withdrawal of the bonus has resulted in substantially lower ore costs, which make possible the reduction in columbium alloy prices.

Union Carbon and Carbide Corp. announced through its division, Electro Metallurgical Co., new base prices of $6.90 per pound contained columbium and $4.65 per pound for columbium-tantalum. Kennametal, Inc. reduced its price

Every day is Saturday... *at Belmont!*

If our ingots were infantrymen, they'd blow their tops! For every day—and all day—is inspection day at Belmont.

Not a single drop, square, stick, grain or ingot "gets by" the critical eye of Belmont metal experts in anything short of perfect condition... at any stage of production.

And Belmont quality is exceeded *only* by Belmont service—the result of 59 years of "falling in" on time.

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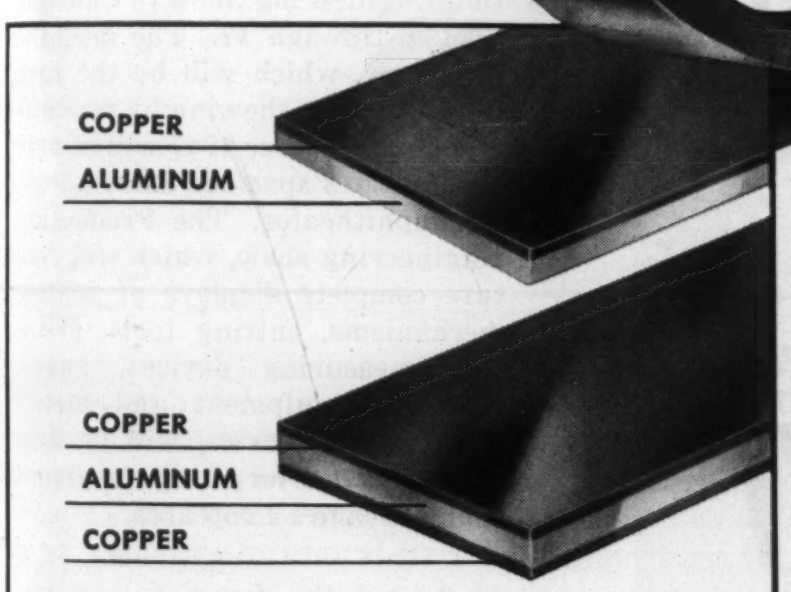
Does At Less Cost



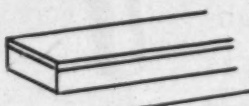
ALCUPLATE FEATURES

- Natural copper appearance
- High electrical conductivity
- Excellent heat dissipation
- Soft-soldering surfaces
- Easy fabrication
- Light weight

Q *How can you reduce the cost of copper or brass in your parts or products?*

A *Get the same copper surface area and natural thickness with less copper.*

And that is *exactly* what ALCUPLATE does. ALCUPLATE is a solid layer of copper permanently clad — to one side or both sides of less expensive aluminum.

THUS  ON ONE SIDE

OR THUS ON BOTH SIDES

THIS gives you solid copper performance at a 15 to 30% lower cost over solid copper.

Yet, in addition to this cost reduction, ALCUPLATE provides virtually the same physical and electrical properties as solid copper.

FABRICATING PROPERTIES

ALCUPLATE can be fabricated by stamping, drawing, spinning and forming. The copper provides an ideal surface for soft-soldering operations, electroplating or other finishes.

SIZES AVAILABLE

ALCUPLATE is available in coils or flat stock up to 1/16" thick x 13" wide and in a choice of thickness ratios and tempers.

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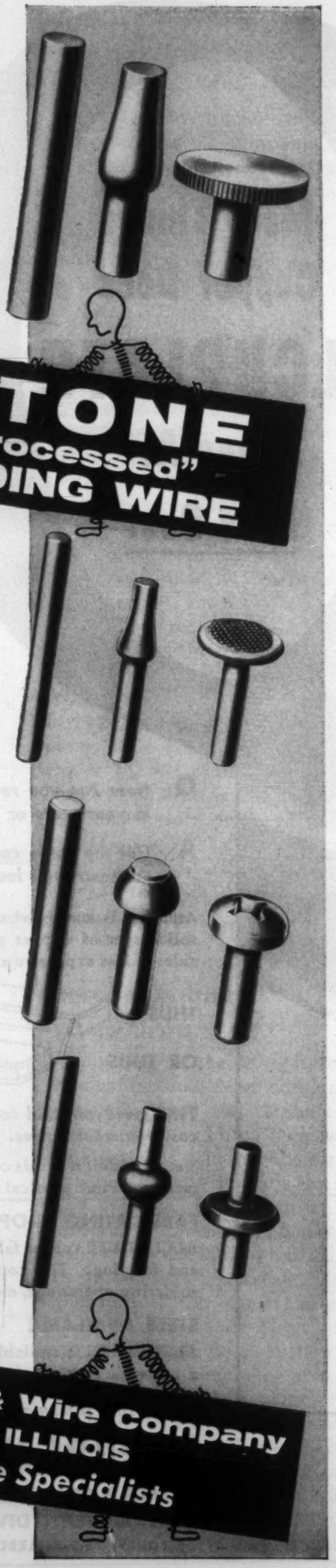
Wire that's *BEST* for difficult cold heading



KEYSTONE
"Special Processed"
COLD HEADING WIRE

The terrific displacement of metal during the cold heading process requires a wire that's *processed specifically* to meet the exact requirements of the job.

In plants where Keystone "Special Processed" Wire is specified for difficult cold heading, production records show these valuable results: (1) increases the production rate which *lowers cost per unit;* (2) greatly prolongs die life which *reduces machine down-time and labor costs;* (3) provides higher quality finished products which *minimizes rejections and inspections.*

Call on our wire specialists for assistance on any problem concerning steel wire. Contact your Keystone representative or write direct.

Keystone Steel & Wire Company
PEORIA 7, ILLINOIS
Industrial Wire Specialists

For more information, turn to Reader Service Card, Circle No. 341

News Digest

of ferrocolumbium to $6.80 per pound contained columbium.

In making the announcement for Kennametal, Philip M. McKenna, President, expressed the view that manufacturers of stainless steel and steel alloys are assured of a plentiful supply of ferrocolumbium at favorable prices for the next few years. The price of the alloying element has been as high as $12.00 per pound for contained columbium during the government stockpiling bonus era.

Toolmen to Hold September Meeting

The National Machine Tool Builders Association will hold its Machine Tool Show and Production Engineering Show in Chicago, Sept. 6 through 17. The machine tool show, which will be the first industry-wide showing by machine tool builders since 1947 will be held in Chicago's spacious International Amphitheater. The Production Engineering show, which will feature complete displays of control mechanisms, cutting tools, precision measuring devices, gages, electrical equipment and metalworking accessories, will be held on the Navy Pier on the lakefront near Chicago's Loop area.

Plastics Society Plans NY Show

New York City's huge new Coliseum, scheduled for completion early next year, has already signed up a major materials exposition. On June 11, 1956, the National Plastics Exposition will return to New York after an eight year absence for the biggest show —at least in terms of leased space —in its history.

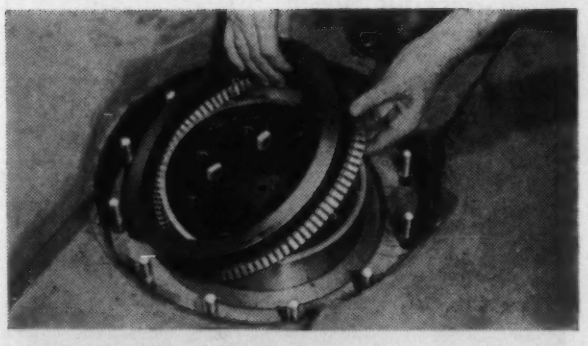
The Plastics Exposition is sponsored by the Society of the Plastics Industry, Inc., an organization composed of representatives of all phases of the plastics field. The Exposition will include displays of

Low-cost, easy-to-form "Beryldur" makes expander spring that requires no adjustment

This finger spring is a U packing expander which maintains a seal at 0-5 pounds in the cylinder of a hoist.* What are the characteristics demanded in an application of this kind? First, corrosion resistance. "Beryldur," like all beryllium copper alloys, is highly corrosion resistant. Second, uniform spring pressure. If the expander is too loose, the packing will leak oil and water. If it is too tight, it will prevent the plunger from moving freely. It is enough to say on this point that this "Beryldur" expander never needs field adjustment.

Finally, formability is all-important. The 130° bends parallel to the rolling direction around a 1/16" radius could cause trouble—but in "Beryldur," grain direction is uniform and blanking is no problem. The expander was originally made of 12 6-in. sections riveted together; now it is made of two strips of mill-hardened "Beryldur."

The properties of "Beryldur" are midway between those of high-strength and high-conductivity "Berylco" Beryllium Copper alloys. "Beryldur" therefore has a higher tensile strength than brass or bronze, plus high fatigue strength, great resistance to wear, and good electrical conductivity. For sample material or engineering help, call or write any of the offices listed below.



"BERYLDUR" EXPANDER is pushed down over plunger, then U packing is forced over the expander.

FURTHER INFORMATION about "Beryldur" is contained in this 4-page folder. Send for your free copy today.

BERYLCO ®

*Made by Globe Hoist Co., Des Moines, Iowa, Philadelphia, Pa.

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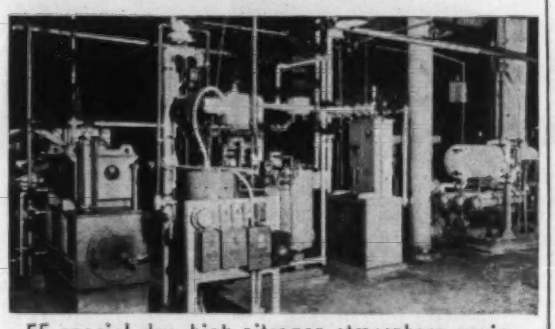
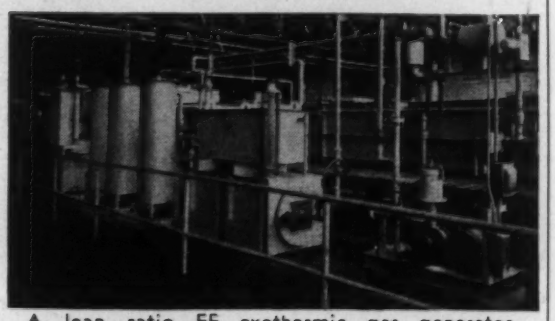
EF FURNACES and SPECIAL ATMOSPHERE EQUIPMENT



EF special dry, high nitrogen atmosphere equipment consisting of an exothermic generator, a CO_2 removal unit, a refrigerator type dehydrator, and a dryer for producing a dry, high nitrogen gas with low H_2 content suitable for bright annealing steel and non-ferrous products.

Get the exact surface characteristics you want, with unvarying uniformity day after day, with EF special atmosphere equipment. Complete facilities. Designed and ruggedly built for efficient, low cost operation.

The complete line includes endothermic and exothermic generators, ammonia dissociators, refrigerators, dryers, desulphurizers, gas scrubbing units, CO_2 removal units and other needed equipment. Automatically controlled. For the utmost in efficient, low cost operation consult EF engineers, headquarters for special atmosphere equipment—and heat treating furnaces.



A lean ratio EF exothermic gas generator, with desulphurizers and refrigerator, produces the special atmospheres for the EF continuous bright annealing furnace shown in background. This installation is in a large copper and brass wire mill.

BULLETIN No. 461
shows typical installations of EF Gas-fired, Oil-fired and Electric Furnaces
Send for a copy today!

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News Digest

raw materials, machinery, processes and end products.

The Exposition will include a conference on plastics featuring marketing analyses and plastics applications. Emphasis will be on expanding outlets for plastics products, new applications in construction, the effect of new processes on plastics manufacture, plastics packaging and new forming techniques.

The chairman of the committee planning the exposition is William C. Conroy of Erie Resistor Corp. Information on the details of the exposition and conference can be obtained from the main office of the Society of the Plastics Industry, Inc., 67 West 44th St., New York 36, N. Y.

Predicts Increase in Malleable Iron

Speaking at the annual meeting of Malleable Founders' Society recently at the Greenbrier, White Sulphur Springs, W. Va., President Charles E. Brust predicted a continued high level of malleable casting production for the balance of this year. Mr. Brust is president of Eastern Malleable Iron Co., Naugatuck, Conn.

"Such predictions are, of course, qualified by conditions in the automotive industry," Mr. Brust said. "However, it is not unreasonable to anticipate total production for the year on the order of 950,000 tons, which would be an increase of approximately 15% over 1954. Shipments in March were the highest for any single month in history —102,364 tons. With a very high level of business activity for the balance of the year, as now predicted by some forecasters, total shipments for the year could conceivably surpass the all-time record high of 1,080,000 tons in 1951."

A feature of the Society's annual meeting on June 16 was the presentation of the McCrea Medal for outstanding service to the indus-

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125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

FREE—Tempil® "Basic Guide to Ferrous Metallurgy" —16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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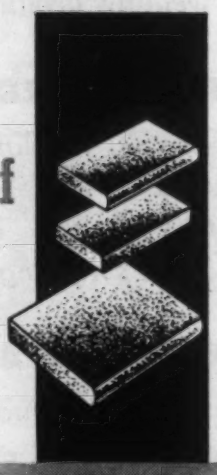
for the fast, low-cost fabrication and repair of heavy equipment.

CARBON SOLVES DESIGN, ENGINEERING, AND PRODUCTION PROBLEMS

Light weight, corrosion-proof CARBON PUMP VANES

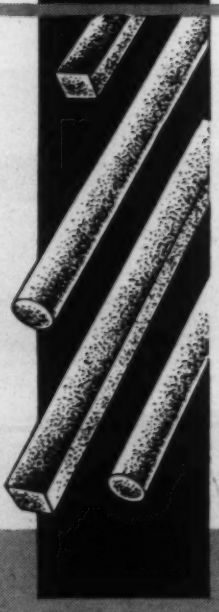


Vanes of Stackpole carbon-graphite for automotive rotating pumps are low in cost, light in weight and are made to close tolerances. Thanks to their chemical inertness, self-lubricating qualities and other factors, they are ideally suited for pumping air, corrosive chemicals or gases.

OIL SEALS that minimize pitting and blistering

Molded from carbon and graphite sometimes balanced with resins or metal powders to meet specific operating requirements, Stackpole seal rings are available in grades, types and sizes for almost any need. Recently developed grades greatly minimize pitting and blistering.

CARBON RODS for salt bath rectification



Stackpole rods are highly effective in avoiding decarburization of metal in heat treating by electric salt baths. Furnace electrode life is increased 4 to 6 times. Sludge formation and salt "drag out" are minimized. Greater fluidity of bath assures much faster, completely uniform heating.

STACKPOLE CARBON COMPANY
St. Marys, Pa.

STACKPOLE

Quality Products—backed by the keen personal interest and cooperation of the specialists who engineer them

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News Digest

try, to William A. Kennedy, Supervisor of Products of Grinnell Co., Providence, R. I. This annual award is named in honor of Charles H. McCrea, former president of National Malleable and Steel Castings Co. of Cleveland.

At a meeting of the Board of Directors of the Society, Carl L. Liebau, President and Treasurer of Federal Malleable Co., West Allis, Wis., was elected President of the Society for the new fiscal year. Mr. Wise was elected Vice President, and Dudley V. Walker, Managing Director of Eberhard Mfg. Co., Div. of Eastern Malleable Iron Co., Cleveland, was reelected Treasurer. Lowell D. Ryan, of Cleveland, was elected to another term as Secretary-Managing Director.

More Shapes from Tube Spinning

A high speed spinning process first used to produce tapered aluminum street lighting poles has been successfully adapted to copper, steel, brass, and a number of aluminum alloys. Now in use at Hubbard Aluminum Products, the configuring process produces a number of shapes that are concentric with the axis of the tubing.

The size range for the process is from a maximum diameter of 10 in. to a minimum of ½ in. The tubing is shaped, by spinning, then can be formed or bent. Maximum lengths up to 40 ft can be spun on present equipment.

The company reports that considerable production economies are effected by the multiple spinning process. In making tapered rollers for conveyors, the configured tubing eliminated two press operations, a weldment, and a special finishing treatment.

The process is still being improved, although items such as ski poles, shuffleboard poles, furniture legs, hose nozzles, pedestals, aircraft parts and lamp columns are now in production.